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VISUALIZATION OF THE RETICULO-ENDOTHELIAL SYSTEM BY THE INJECTION OF COLLOIDAL THORIUM DIOXIDE (THOROTRAST)*

AN EXPERIMENTAL STUDY

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VISCERAL visualization by roentgenologic means has, until recently, been practically limited to the cavernous viscera such as the gastrointestinal tract, genitourinary system, gallbladder and bronchial tree. The parenchyma of solid organs such as liver and spleen have resisted visualization by the methods applied to the other organs. When cholecystography was being developed it was believed that it might conceivably lend itself also to hepatic visualization since the halogenated compounds used were eliminated via the liver. This proved a false hope as the dose required for such a purpose was far too toxic (Einhorn and Stewart[7]). Keith and Briggs[19] tried gum acacia emulsions of halogenated oils in animals with results one would hardly call satisfactory.

The desiderata for successfully visualizing, roentgenographically, the parenchyma of solid organs as liver and spleen are: (1) a non-toxic substance; (2) a substance which is withdrawn from the circulation and stored a sufficient length of time to make feasible subsequent roentgenography; (3) it must be uniformly distributed throughout the organs to obviate distorted or false pictures.

Oka,[24] in Tokio, experimented with colloidal suspensions of thorium which he introduced as tordiol. Using fairly small doses he was able to visualize the spleen. Tordiol, however, when introduced into the blood stream causes flocculation and is extremely toxic. Radt[27] elaborated upon his method and by increasing the dose was also able to demonstrate the liver as well as the spleen. The substance which he developed and which we have used is called thorotrast.† This is a 25 per cent thorium dioxide colloidal solution containing 22 per cent of metallic thorium. This is superior to tordiol because it does not create flocculation of organic fluids such as serum, and thus obviates the danger of capillary em-

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† The Heyden Chemical Company of New York were kind enough to furnish us with the thorotrast used in the experimental work.

boli. Thorotrast is stable and hence suitable for intravenous use. Within a few minutes after its injection, thorotrast disappears from the circulation and is taken up by the reticulo-endothelial system.

Hepatosplenography is conditioned by the fact that the reticulo-endothelial system plays the predominating rôle in withdrawing thorotrast from the circulation shortly after injection. Ever since Aschoff and Landau first introduced this term in 1913 to describe this system of cells, there have been controversies regarding its morphology, derivation, function, etc. It is now recognized that cells derived from reticular and endothelial elements exist in the spleen constituting the major portion of this organ, liver (Kupffer cells), the bone marrow, lymph nodes, lymphoid tissue and as the histiocytes in the general connective tissues. The question of the functional unity of the reticulo-endothelial system is confirmed by the distribution of thorotrast in the body. The phagocytic qualities of these cells are demonstrated by the readiness with which they engulf the minute particles of thorium dioxide just as it was shown previously with India ink and other colloidal suspensions.

DOSAGE

The ideal dosage is obviously the minimum amount of thorotrast required to render the liver and spleen opaque. On occasion one may merely wish to outline the spleen and liver, in which case considerably less is required. For complete opacification it is necessary to give about 1 c.c. per kilo of body weight. Thus, the usual human dose is approximately 50 to 75 c.c. It is usually given in 5 to 10 per cent glucose or normal saline solution and administered intravenously very slowly, the mixture having been warmed to body temperature. Menville and Ané,[23] in studying the subcutaneous injections in animals, noted the complete absence of slough or abscess. Yater and Otell[33] found it unnecessary to dilute the thorotrast as supplied and even advocated a regular human dose regardless of weight. This conforms with our experience as the patients showed no change in response to diluted or undiluted thorotrast. No preparation of the patient is necessary; it may be given fasting or post prandial. All observers are agreed that it is best given in fractional doses, either every day or every other day, depending upon the patient's condition, reaction, etc. The most common procedure is to divide the total calculated amount into three doses. In the case of any immediate reaction the succeeding fractions should be smaller and hence the total dosage will be received over a longer period of time.

REACTIONS

There need be little concern regarding any immediate reactions. A slight rise in temperature and transient feeling of uneasiness or slight headache may occur. In the event of even a slight reaction to the early doses, the following doses should be given in smaller fractions such as 10 or 12 c.c. Thorotrast is non-irritating to the veins and does not predispose to venous thrombosis. Thus, in one rabbit as many as 93 injections have been given undiluted in the marginal ear veins. In thorotrast we are dealing with particulate-like matter which unlike organic or inorganic tissue poisons or bacterial toxins has practically no immediate ill effects. Enormous doses have failed to produce any immediate reactions. We have injected 36 c.c. into a rabbit which survived about twenty-four hours, and Randerath[28] reports a case of a man of fifty-eight who received 180 c.c. in divided doses extending over a period of fourteen days.

The mere absence of any important immediate toxic effects does not free us from considering the remote effects of the presence of thorotrast in the tissues over so long a period. A factor not to be neglected is the possible persistence of minute amounts of radioactivity in the substance itself. The tragic sequel which took place in the luminous dial workers some of whom

began to show bone necroses from seven to ten years after their exposure should make us pause in the consideration of this feature. We are assured by chemists that any such fears may be allayed. According to Yater and Otell, tests performed at the U. S. Bureau of Standards for them showed that the radioactivity of thorium dioxide solution is negligible. Measurements by Dr. Blumgart, utilizing the Geiger counter, likewise reveal a minute quantity of radioactivity. Kadrnka and Oliver consider the radioactivity of thorotrast negligible.

There still remains the question of the transformation of the thorium dioxide into mesothorium. Mesothorium conveys radioactivity and is responsible for the remote toxic effects on bone and other tissues. Sabin et al.[29] subjected rabbits to intravenous injections of radium chloride and mesothorium and report the development of osteogenic sarcoma in 2 out of 7 rabbits surviving from eleven to nineteen months.

The question of secondary radiation being induced in tissues has also been studied but none has, as yet, been detected. These hypothetical questions, theoretical in nature, can only be answered when sufficient time has elapsed to observe long time effects or when actual laboratory experiments can demonstrate conclusive results.

The persistent presence of various other foreign substances uniformly distributed throughout the liver has eventually led to destructive processes or cirrhotic changes. It is conceivable that a sufficient number of liver cells may undergo necrosis, stroma replacement and eventually form foci of sclerosis as a result of contraction and condensation of the stroma. Mallory[22] has demonstrated such changes in relation to pigment cirrhosis. Following thorotrast, microscopic examination* of sections of the spleen and liver reveals the granules throughout the reticulo-endothelial system. Huguenin et al.[15] succeeded in producing hepatitis and cirrhosis in rabbits by injecting very large doses (15 to 20 c.c.). This, however, is about 10 times the dosage required for visualization purposes. The type of cirrhosis and hepatitis reported by Huguenin and his coworkers bears a resemblance to the experimental cirrhosis induced by tetrachlorethane reported by Bollman and Mann.[5] Popper and Scholl[26] applied the Millon reaction for liver function and believe they detected evidence of liver injury in one case. On the other hand, animals kept under observation for two years after thorotrast have appeared perfectly normal. One of our rabbits (No. 301) receiving 93 injections of very small doses totaling 21.46 c.c. revealed no unusual features at the end of almost one year. His appetite was unimpaired and he showed no weight loss.

Tripoli and Haam[31] report that "No gross changes nor any evidence of any type of hemorrhage was noted in animals receiving 0.8 grams per kg. body weight, irrespective of time elapsing between final administrations of the drug and death, ranging from one day to 6 months."

ELIMINATION

As previously mentioned, one of the disturbing features regarding thorotrast is its persistence in the tissues where it is deposited. Plates taken months after the injection still show the presence of thorotrast in fairly large quantities in the liver and spleen. Neither the route nor the rate of elimination has been definitely determined. There is a great discrepancy of opinions regarding this question, varying from the statement that there is a 50 per cent reduction in a few months to almost no elimination after two years. Leipert[21] quantitated chemically the residual thorium in the tissues in a few experiments and the only conclusion to be drawn from his preliminary work is the persistence of the thorium in several tissues; this of course coincides with what we see on the film. The absence of criteria for (1) evaluation of the normal size of liver and spleen and

* We are indebted to Dr. Monroe Schlesinger of the Department of Pathology for the gross and microscopic examination of all the organs.

(2) of definite comparisons of opacity intensities has been a marked deterrent in forming conclusions. There is no doubt that thorotrast is very slowly eliminated. Several months after the injection marked opacity of liver and spleen is still demonstrable.

The problem of elimination is still a subject of investigation. Most of the evidence points to the bile and urine as the chief routes of elimination. Amell Sans[1] regards it as being entirely eliminated by the liver. Many granules have been found in the phagocytic cells of the upper respiratory tracts, from where it is assumed they are ultimated excreted.

It would prove advantageous if measures could be found which would increase elimination. We have found that sodium thiosulphate in several rabbits produced no appreciable change. Decholin, a powerful cholagogue, however, proved far more promising. Although our results are too meager to report in detail, it appeared that in a few rabbits we were able to observe a decrease in the intensity of the liver (and spleen) shadow simultaneously with the presence throughout the gastrointestinal tract of dense granules, presumably thorotrast. This study is to be pursued further.

No consistent results have been reported regarding the blood changes except for the transitory leukopenia followed by a longer phase of leukocytosis. This reaction is similar to that observed after injection of most of the other colloidal substances. Lambin[20] states that 5 c.c. per kg. caused an anemia and 1 c.c. resulted in a transient erythroblastic reaction. This has not been confirmed. We believe his dose for hepatic visualization in the rabbit is much too large. Shih and Jung[30] report an experimental thrombocytopenic reaction in a few rabbits. Yater and Otell found no significant changes in their platelet counts made before and after injection in many patients. Hemorrhagic phenomena of various kinds were encountered by Pedro Pons and Vilaseca Sabater,[25] especially in cases with hemorrhagic tendency. At the end of almost a year our rabbit No. 301 showed a red blood count of 6,810,000. Vara-López[32] found no alterations in the blood constituents, albumin, globulin, fibrinogen, cholesterin, number of red blood cells, leukocytes, leukocyte formula, hemoglobin and sedimentation velocity. Gottlieb's[9] results were also negative.

GENERAL CONSIDERATIONS

The spleen and liver stand out in marked contrast to the other organs, in some cases the liver, and in others the spleen being more dense. The reason for this variation is not entirely clear. In rabbits it appeared that if the initial injections were given in larger dosage, the spleen became the organ of greater density, whereas with very small dosage and frequently repeated injections, the liver showed its opacity earlier and was more marked than in the spleen (compare Figs. 1 and 7).

LIVER

The normal liver appears uniformly increased in density except where major vessels exist. These can be made out as non-opaque arborescent trunks within the parenchyma. In the rabbit the distinct lobes stand out prominently. After the thorium dioxide is well taken up, the liver assumes a granular appearance. Only the outline of the liver will appear if the total dose is reduced to about 30 c.c. In cases where there is free fluid in the abdomen, the liver can be seen separated from the costal border. The absence of reticuloendothelial tissue from any cause results in the failure of that portion of the liver to take up the thorotrast. Thus, carcinomatous areas, abscesses, cysts, etc., are indicated by negative shadows surrounded by a thorotrast-laden denser shadow. Irwin[16] has found some thorotrast granules in the hepatic cells, other than the Kupffer cells.

SPLEEN

The spleen may appear partially or totally visible. In rabbits, if the spleen is only partially visible the tip almost invariably appears denser. The granular ap-

pearance is present in the spleen as well as the liver. Examinations of numerous roentgenograms reveal the inconstancy of size, shape and position of the spleen as previously recorded by Barcroft, the British physiologist.

Barcroft[2,3] studied the alterations in the volume of the normal spleen by different methods, prior to the development of the thorium dioxide method. First he placed small metal clips along the edge of the spleen and then studied the roentgenograms taken in the horizontal and vertical planes. From these photographs linear outlines of the spleen were made. Secondly, he exteriorized the spleen permanently and recorded the gross alterations under various physiological conditions such as pregnancy, blood transfusion, hemorrhage and asphyxia. The outstanding observation was the marked variability in the size of the spleen under different conditions. Izquierdo and Cannon[17] have described the reaction to emotion. Cannon has attributed to the spleen some importance in his "emergency" theory, probably mediated through the liberation of adrenalin which has been regarded as a splenic contracting agent, thus liberating an appreciable quantity of red blood cells among its other effects.

These variations in the size and shape of the spleen can be visualized more clearly and without resorting to operative procedures by means of thorotrast. At different intervals the roentgenograms show the spleen of the rabbit either small or large, lying transversely or longitudinally, straight or curved and smooth in contour or markedly indented. This latter feature we interpreted as representing the peristaltic-like contractility of the smooth muscle residing in the spleen.

Haam et al.[10] have specifically studied splenic contraction in various animals by means of thorotrast. Adrenalin definitely produced a contraction of the spleen in the dog. Simultaneous with the adrenalin injection hematocrit readings were taken. They noted an increase of 23 per cent in the hematocrit values of the peripheral blood three minutes after the contraction of the spleen. This was repeated often enough to indicate a definite correlation between the contraction of the spleen and the increase in the peripheral hematocrit reading. In their experiments with guinea pigs and rabbits only slight, if any, contraction of the spleen was produced after such measures as adrenalin injection, bleeding or shock. In a few experiments of ours, confined to rabbits, adrenalin produced no appreciable changes. The cause of the variations noted on our roentgenograms we were unable to ascertain and have regarded them as physiological.

OTHER ORGANS

Following intravenous injections, the spleen and liver act as the first filtration stations. Experimentally, larger injections cause other elements of the reticulo-endothelial system to take up the thorotrast. Thus, in rabbits we may note the paravertebral glands, adrenal cortex and bone marrow on the roentgenogram (see Fig. 5). The roentgen appearance of the infiltrated bone marrow with thorotrast presents a characteristic picture. The medullary canal of the bone appears as a dense granular column distinctly delineated from the cortex, the intensity depending on the concentration of thorium in the marrow tissues, varying from a cloudy granular appearance to a metallic density. Although best demonstrated in the long bones and the ribs, all the bones are involved. Subcutaneous injections lead to local glandular absorption, as demonstrated by Menville and Ané.[23] They were able to visualize these glands within a few days following injection. We have noted that the lungs at times become more dense, although because of the rapid respirations, interpretation is more difficult. Only microscopic amounts have ever been found in the kidneys and the testes appear to be free from thorotrast. In none of the roentgenograms could we detect any evidence of deposition of thorium in the genitourinary tract as represented chiefly by the kidney and

Fig. 1. Spleen and liver clearly defined. Note greater density of spleen. The variation in the shape of the spleen is well exemplified in this series. Arrow points to skeletal outlines of pregnancy which took place after injection of thorotrast.

testes. Combined hepatosplenography and intravenous pyelography was performed on several rabbits and we failed to note any mutual interference in these procedures. Fetzer[8] secured similar results. Held[13] followed the resorption of thorotrast after injections into the peritoneal cavity. He first noted the absence of local irritative phenomena. The particles were then absorbed via the subdiaphragmatic lymphatics. He states that after eight days a strong splenic shadow was demonstrable and the abdominal cavity was almost free from thorium. He concludes that the passage from the lymph channels into the blood takes place through the bronchomediastinal trunk and not through the thoracic duct as is the case with the coarser colloidal suspensions.

INDICATIONS

Thorotrast is primarily a diagnostic agent, and may be utilized in differentiating a large number of conditions: (1) hepatomegaly or splenomegaly; (2) the presence of a mass in the region of the liver or spleen where doubt exists as to whether it is liver or spleen or some other viscus or condition; (3) in cases of carcinoma of an abdominal viscus with suspected metastases in the liver, thus possibly obviating unnecessary surgery; (4) abscess of the liver in a case of obscure sepsis; (5) cysts of the liver and spleen; (6) differentiation between the spleen and kidney; (7) cirrhosis of the liver; (8) infarction of spleen; (9) syphilis of liver (hepar lobatum); (10) thrombosis of the splenic vessels. Beutel[4] diagnosed one such case confirmed by autopsy; and finally (11) it opens up a new field for study of the physiology of the liver and spleen and the reticulo-endothelial system.

CONTRAINDICATIONS

We feel strongly that so long as there remains even a slight element of potential remote effects, thorotrast should not be used in children or young adults, with rare exceptions. Severe liver or renal disease or both together is regarded as a definite contraindication. Opinions vary in the case of cirrhosis of the liver and judgment should be based on the individual case, though most of the reports reveal no untoward effects. Wherever other and simpler diagnostic measures are applicable, thorotrast should not be resorted to.

RELATION TO IMMUNITY

Because of the avidity of the reticulo-endothelial system for thorotrast, it was thought that immunological processes might be altered as a result of reticulo-

endothelial block. A number of studies have all yielded negative results. Kadrnka and Rossier[18] injected India ink prior to the thorotrast and state that it did not "block" the reticular cells. Held[11,14] studied the influence of storage of thorotrast on the course of pneumococcic infection in white mice and found that the defensive powers against infection were relatively little influenced. He[12] also obtained very slight effects on the hemolysin titer of the blood after injection of thorotrast. On the other hand, Büchner[6] claims that the retained thorotrast produces functional weakening of the reticulo-endothelial system.

EXPERIMENTAL WORK

Our preliminary experimental work was conducted with rabbits. The endeavor was made to record observations regarding the toxicity of thorotrast in various dosage, the effects of prolonged residence of the thorium in the tissues and the question of elimination.

Thorotrast was given intravenously to 25 rabbits in varying dosage and at varying intervals. A few specimen protocols are presented to illustrate some of the changes accompanying these factors. Doses smaller than 1 c.c. per kg. failed to enhance the visibility of the liver or spleen in the rabbit. As the doses approached 1.5 c.c. these organs could then be made out. Figure 1 represents the spleen and liver following a dosage of 1.7 c.c. per kg. (Table I). The spleen is clearly defined and the liver, particularly the left lobe, can easily be seen. Increasing the dosage at first merely intensifies the opacities of these organs. Further increases lead to an inability of the spleen and liver to take up all the thorium and we begin to note deposits in other structures such as the paravertebral glands (see Table II and Fig. 2). Similar results follow if the increased dosage is given fractionally and within a few days to a few weeks of each other (see Table III).

The bone marrow constituting an important portion of the reticulo-endothelial system becomes visible when the dosage is very large. Figures 3, 4 and 5 represent this state of affairs after a huge dose of 30 c.c. (15 c.c. per kg.) in two doses of 12 and 18 c.c. Incidentally this rabbit survived almost six months after the injections of these enormous doses representing 10 to 15 times the visualization dose. The visibility of the bone marrow is indicative of the

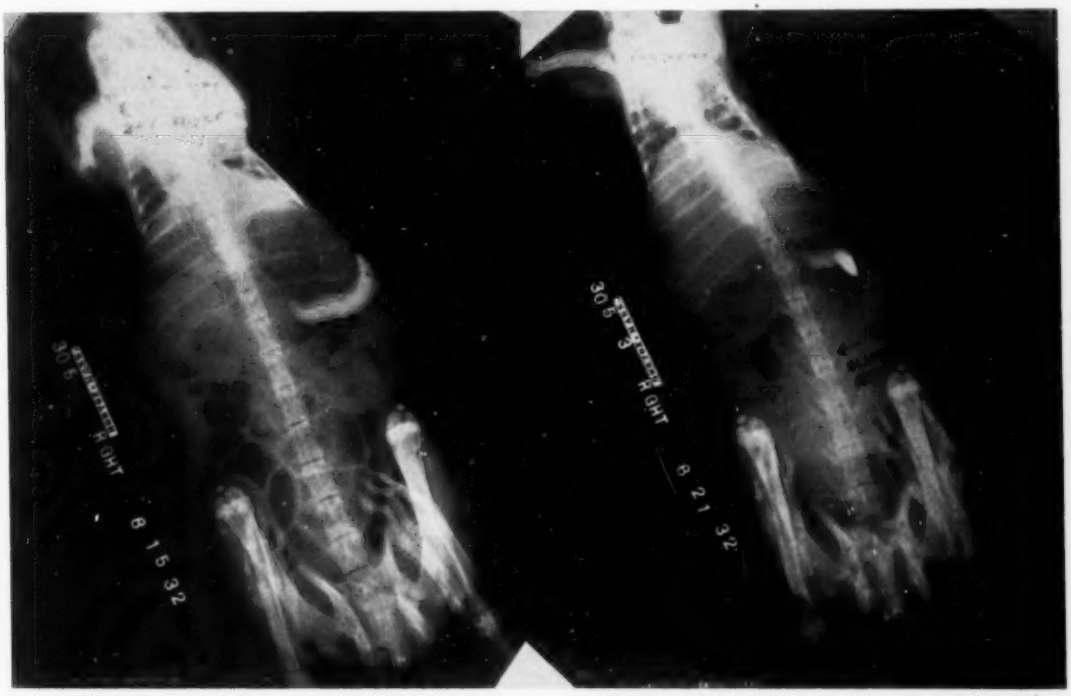

FIG. 2. Twenty-four hours after 3.1 c.c. per kg. In addition to its presence in liver and spleen thorium is noted in the paravertebral glands.

FIG. 3. Two months after injection of massive dose of thorium. Paravertebral glands are well outlined.

activity of this tissue in filtering out the excess quantity of injected thorium.

In contrast to this type of experiment another animal received a large number of small injections (see Table IV). There are a number of unusual features in relation to this rabbit. One of our aims was to establish the tolerance of the rabbit to repeated small doses as 0.1 c.c. per kg. The total number of injections given was 93 and the total dose was 21.46 c.c., an amount equivalent to about 15 times that necessary for ordinary visualization purposes. The change from the large to the small and frequent doses yielded the important observation that the liver and not the spleen first became opaque (see Figs. 6 and 7). Another rabbit received 12 injections of 0.3 c.c. over a period of two weeks and showed similar results. This is in direct contrast to the usual findings. This particular type of experiment, so far as we are aware, has never been reported. The first appearance of slight opacity in liver occurred on about the fifth day after injections were begun. At this time he had 0.92 c.c. total and 0.5 c.c. per kg.

Because of the increasing opacity of liver, then spleen, and then bone marrow, as shown on the film, it was evident that the rate of elimination was certainly far less than 0.1 c.c. per kg. daily. The trinity of liver, spleen and bone marrow as the major elements of the reticulo-endothelial system seems further confirmed.

Rabbit No. 301 received 21.46 c.c., an amount more than sufficient to damage if not destroy such organs as the liver and spleen and also to inhibit spermatogenesis, which is a very sensitive index to the degree of radioactivity exerted upon the organism. In the face of such dosage it certainly was surprising to note at post mortem, active spermatogenesis as well as the presence of the normal architecture of the liver and spleen after so many months of

TABLE I

RABBIT—313

Date	Dose	Wt.	Dose per Kg.	X-Ray appearance of				Remarks
				Liver	Spleen	Bone Marrow	Other Organs	
1933	*c.c.*	*grams*						
1/5	4.5	2550	1.7 c.c.					
1/30		2890		x	xx	o	o	Spleen has a mottled appearance.
2/8		3030		xxx	xxx	o	o	
2/16		3080		xxx	xxx	o	o	Spleen is markedly enlarged. Skeletal outlines of multiple pregnancies. Placenta not visible. Rabbit miscarried.
2/18								
3/10				xxxx	xx	o	o	Spleen considerably smaller—less dense and less mottled. Liver much denser.

exposure. Irwin reports experiments on 25 rabbits over a four month period with doses up to 5 c.c. per kg. In addition to the liver and spleen he found a minute amount of thorotrast picked up by the adrenal gland and ovary. He concluded that "the presence of ThO_2 was innocuous in the tissues and no untoward reaction due to its presence has been observed in doses up to 5 c.c. per kg. during a period of 4 months."

Mention has previously been made of the marked variation in size and shape of the spleen. These few films depict these changes clearly. These changes were even more striking in our complete series.

From this preliminary experimental work certain conclusions seem warranted. For visualization purposes the rabbit is an adaptable animal. The comparative dose, however, is somewhat larger than that required for humans, 1.5 to 1.75 c.c. per kg. being necessary. There were no immediate reactions and in doses well beyond that required for visualization purposes the animals showed no ill effects as far as appetite, weight, blood counts, unusual susceptibility to infections and gastrointestinal functions were concerned.

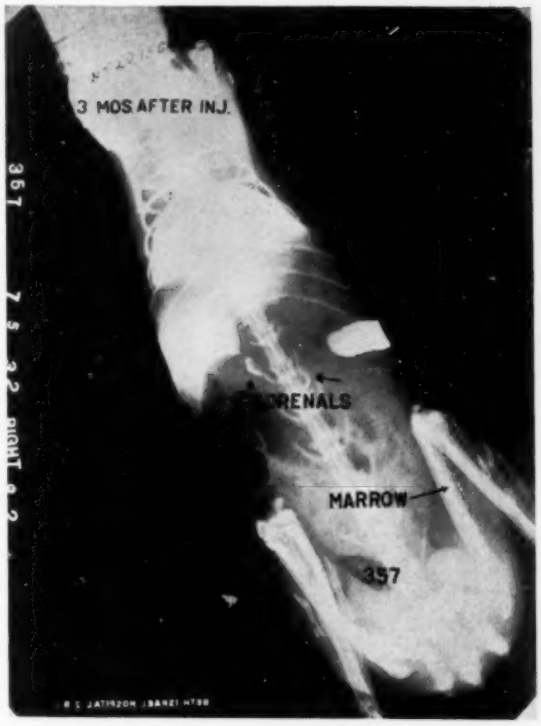

FIG. 4. Later appearance following massive dosage. Liver, spleen (folded on itself), marrow and adrenals easily discernible.

CASE REPORTS*

We have now given thorotrast to a considerable number of patients. It is not our purpose at this time to analyze our whole series but rather to present a few representative cases to indicate the diagnostic potentialities of this method. A subsequent report will deal with the clinical phases of our whole series.

* We wish to express our thanks to Dr. Harry Linenthal and Dr. Hermann L. Blumgart of the medical service and Dr. Charles Mixter of the surgical service for their courtesy in allowing us to utilize cases from their services.

CASE 1. C. P., Jewish, white, male, aged forty, entered the hospital on August 31, 1933 complaining of abdominal distress and cramps

TABLE II

RABBIT—305

Date	Dose	Wt.	Dose per Kg.	X-Ray Appearance of				Remarks
				Liver	Spleen	Bone Marrow	Other Organs	
1932	*c.c.*	*grams*						
6/14	6.0	1940	3.1 c.c.					
6/15				o	xxx	o	Paravertebral glands x	Spleen is uniformly opaque and has a granular appearance.
6/21		1880		xx	xxxx (Tip)	o	Paravertebral glands xxx	Spleen is much smaller. Opacity of the liver chiefly in the left lobe.
6/27		1883						
7/12		1936						
7/28				xxxx	xxxx	o		Post-mortem x-ray. Spleen of small size.

Fig. 5. Five months after massive dosage. Arrow points to bone marrow.

of two years' duration and increasing in severity. This was followed by constipation with occasional periods of diarrhea. Occasional traces of blood were noted in the stools.

Past history, family history, and marital history were non-contributory.

Physical examination was essentially negative except for the abdomen which presented a visible fullness in the right upper quadrant near the midline, in which area there was a palpable mass of a rocky hard consistency measuring about 7 cm. in diameter with an irregular nodular surface. This mass appeared to be fixed to the surrounding tissues but descended with respiration. By percussion it was contiguous with the liver, although on palpation it seemed to be demarcated from it. There were several hard shotty and pea-sized inguinal glands present. The rectal examination showed a spastic sphincter and several hemorrhoidal tabs. Sigmoidoscopy revealed a definite tumor about the size of a large grape lying on the right and anterior walls about 13 cm. from the orifice. The tumor bled rather easily; there was evidence of obstruction. A biopsy examination was reported as adenocarcinoma of the rectum.

Clinical Pathology. All the examinations of the urine were normal. The blood showed a red count of 4,650,000 with 75 per cent hemoglobin and 7,200 white blood cells. The differential count showed 81 per cent polymorphonuclears and 19 per cent lymphocytes. The stools showed a strongly positive test for occult blood on one occasion, three other positive tests and one was negative. Blood chemistry was as follows: Sugar 83 mg., N. P. N. 30 mg., chloride 436, CO_2 combining power 41.2. The icteric index was successively 10, $7\frac{1}{2}$ and 6.25. The Van den Bergh showed a delayed reaction. Gastric analysis showed no free HCl in the fasting or first specimen. The third and fourth specimens showed free HCl = 8°. The combined acid varied from 10 to 15°.

Roentgenographic studies revealed the following: Barium enema showed the entire colon was well outlined. There were numerous rounded areas of diminished density in the descending colon and in the sigmoid which might be due to polypi, although this might be produced by gas in the bowel. There was also a marked area of spasticity and slight irreg-

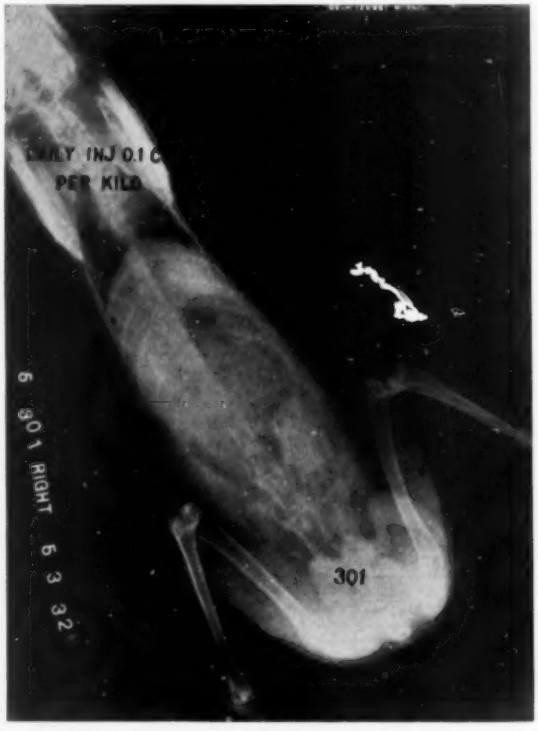

Fig. 6. Rabbit showing effects of minute doses. At time of this roentgenogram animal had received daily injections of 0.1 c.c. totalling 1.09 c.c. Note absence of splenic shadow in contrast to beginning increase in liver density.

ularity at the rectosigmoidal junction. The liver appeared to be very large. The hepatic flexure appeared to be pushed downward. Reexamination five days later showed a definite small filling defect in the upper portion of the rectum near the rectosigmoidal junction which was very suspicious of an early neoplasm. Stomach and duodenum: The stomach was of good tone with active peristalsis. The outlines of both greater and lesser curvatures were regular. The duodenum showed a constant deformity in the first portion of the cap. Six hours after ingestion of the barium, the stomach was emptied and the head of the meal was at the cecum. At twenty-four hours the head of the meal was at the splenic flexure. The colon was slightly spastic. The cecum was slightly redundant, movable and non-tender on roentgenoscopic palpation. Appendix was not seen. Plain films of the gallbladder region showed no evidence of stones of the opaque variety. Dorsolumbar spine, pelvis, skull and long bones showed no evidence of metastatic lesions.

Following the intravenous administration of thorotrast roentgen examination of the abdomen revealed clear visualization of the liver and spleen. The liver appeared greatly enlarged, its lower border coming almost to the posterior crest of the ilium. The shadow was of a homogeneous density except along the superior surface of the liver. The region of the area of rarefaction was regarded as consistent with a metastatic lesion. The left lobe of the liver was slightly enlarged. The spleen was moderately enlarged (see Fig. 8).

Fig. 7. Rabbit after receiving total of 21.46 c.c. in 93 doses. Intensity of liver shadow (metallic) far greater than splenic shadow.

Table III
RABBIT—306

Date	Dose	Wt.	Dose per Kg.	X-Ray Appearance of				Remarks
				Liver	Spleen	Bone Marrow	Other Organs	
1932	*c.c.*	*grams*						
6/14	3.3	2230	1.5 c.c.	o	o	o	o	
6/15				o	xx	o	o	The proximal portion of the spleen shows slight opacity—remainder of spleen very opaque.
6/21		2285		x	xx	o	Paravertebral glands x	Spleen very large, being twice previous size. Splenic density is more homogeneous. The left lobe of the liver shows visible opacity. The paravertebral glands are faintly visible.
6/27	1.6	2410	2.0 c.c.					
7/5				x	xxx			The spleen is very markedly enlarged. Death of animal.
7/10								

TABLE IV

RABBIT—301

Date	Dose	Wt.	Dose per Kg.	X-Ray Appearance of				Remarks
				Liver	Spleen	Bone Marrow	Other Organs	
1932	*c.c.*	*grams*						
4/27	.186	1862	0.1 c.c.	o	o	o	o	
4/28	.186		0.1					
4/29	.186		0.1	o	o	o	o	
4/30	.186		0.1	o	o	o	o	
5/2	.17	1761	0.1	o	o	o	o	
5/4	.17	1761	0.1	x?	o	o	o	Questionable visibility of left lobe of liver. Total to date 1.09 c.c.
5/5	.17	1725		x*	o	o	o	Slight opacity of left lobe of liver.
5/6	.17	1710	0.1					
5/7	.17		0.1	x	o	o	o	Appearance of liver about the same.
5/9	.17	1765	0.1	x	o	o	o	
5/11	.17		0.1	x	o	o	o	
5/12	.17		0.1					
5/13	.17		0.1	xx	o	o	o	The whole liver is now visible—left lobe more marked.
5/14	.188	1888	0.1	xx	o	o	o	
5/16	.184	1845	0.1	xx	o	o	o	Appearance of liver essentially unchanged.
5/17	.184		0.1	xx	o	o	o	
5/18	.184		0.1	xx	o	o	o	Total to date 3.28 c.c.
5/20				xxx	o	o	o	Slight increased density of the liver.
			0.1					
5/21	.184							
5/23				xxx				
5/24	.184		0.1					
(5/25	.20	2000	0.1					
to	Six							
6/10)	Doses			xxxx	o	o	o	Increased density of the liver.
(6/11	.20	2150	0.1	xxxx	o	o	o	
to	Six							
6/18)	Doses			xxxx	o	o	Lungs x	The lungs show increased density. Increasing density of the liver.
(6/21	.20	2290	0.1	xxxx	o	o	o	7/5/32 Total to date 9.86 c.c.
to	13							
7/5)	Doses							
(7/6	.20							Liver very dense. The lower half of the spleen is now vis-
to	.23							
8/8)	Doses	1996	0.1	xxxxx	x	x	o	ible. The entire marrow of the ribs and long bones can be made out. 8/8/32 Total to date 14.6 c.c.
(8/9	.20	2158	0.1	xxxxx	xx	x	o	Liver very opaque. The whole
to	11							spleen now shows uniform
9/2)	Doses							opacity. The liver has a metallic density; right lobe granular. Spleen granular.

Table IV (*Continued*)

Date	Dose	Wt.	Dose per Kg.	X-Ray Appearance of				Remarks
				Liver	Spleen	Bone Marrow	Other Organs	
1932	*c.c.*	*grams*						
(9/3 to 10/26)	.20 15 Doses	2172	0.1	xxxxx	xx	xx		10/26/32 Liver and spleen showed intense density. The bone marrow was plainly visible. Bases of lung show increased density. Adrenal glands visible. Paravertebral glands seen.
11/14				xxxxx	xxxx	xxx		
11/25				xxxxx	xxxx	xxxx	Glands (Paravert.) xxx	The liver and spleen show metallic density. They are both granular. The spleen is enlarged. The bone marrow is plainly visible. More paravertebral glands are seen. Hilus glands faintly visible.
12/13				xxxxx	xxx	xxx	Glands (Paravert.)	
1933								
1/4		2360		xxxxx	xxxx	xxxx	Glands (Paravert.)	The liver is extremely granular. The lower border of the liver is now less dense and shows coarse granulation.
1/30		2370		xxxxx	xxxx	xxxx	xxx	
2/16		2415		xxxxx	xxxx	xxxx	xxx	The lower border of the liver has assumed a streaky appearance.
3/10		2356		xxxxx	xxxx	xxxx	xxx	The lower border of the liver is still streaky. The spleen is now coarsely granular; marked bone atrophy is present.

Total 93 Doses 21.46 c.c.

Total Dose per Kg. 10 c.c.

o = Absence of increased density.
x = Slight increase in density.
xx = Marked increase in density—density of heart.
xxx = Very dense—density of bone.
xxxx = Metallic density.
xxxxx = Intense metallic density.

3/30 accidental death of animal from a fall.

The patient was regarded as inoperable and was referred to the Tumor Clinic of the Out-Patient Department. The treatment he received consisted essentially of a course of roentgen irradiation. He continued to have pain in the upper abdomen, slight cramps and on one or two occasions frequency of bowel movements but he has been quite free from bleeding by rectum. He gradually became cachectic and ascites developed for which several paracenteses were done. A subsequent roentgen examination of the abdomen on October 19, 1933, showed hepatic metastases as previously reported, but the size of the metastases appeared to be slightly larger than at the previous examination. A re-examination on November 25, 1933, showed no definite changes in the spleen. The liver showed areas of destruction throughout. The next roentgen examination was made on March 13, 1934, and showed the liver to be

larger. There was evidence of increased destructive changes in the parenchyma of the liver.

Additional evidence of the presence of intra-abdominal carcinoma was obtained from the microscopic examination of blocked sections of ascitic fluid which showed masses of cells containing a few mitotic figures. The patient grad-

Fig. 8. Arrows point to irregular motheaten areas due to extensive metastases. Large portion of the liver invaded by new growth.

ually declined and died on May 14, 1934. Permission for autopsy was not granted.

Case II. E. L., a Jewish widow, aged seventy-two, was referred to the hospital by Dr. H. Fishbein on September 23, 1932, with the major complaint of enlargement of the abdomen of one year's duration. Other than the awareness of the increasing size of her abdomen she experienced no pain, discomfort, nausea or vomiting.

Past history, family history and marital history were negative.

Physical Examination. A poorly nourished woman whose abdomen is symmetrically protuberant. There is an umbilical hernia and also a right inguinal hernia, the latter with a loop of gut in it. Occupying almost the entire left side of the abdomen there is a hard firm mass. This is felt on the left side of the abdomen extending posteriorly until it is lost deep in the muscles of the back; superiorly this mass is seen to come under the costal margin on the left side. It extends down parallel to the long axis of the body, and it does not cross the midline. Inferiorly it is felt to extend 3 or 4 fingerbreadths on the left side below the crest of the ilium, into the false pelvis. This mass moves somewhat with respiration. It is very firm. Its surface is generally smooth. No distinct notch can be made out. It is flat to percussion and it is not tender. No shifting dullness in the abdomen, and abdominal reflexes are obtained; no costovertebral tenderness. The liver is felt to 2 or 3 fingerbreadths above the crest of the ilium, the surface is smooth, not unusually firm and it is not tender.

Clinical Pathology. Urine showed a very slight trace of albumin with numerous white cells in the sediment in the non-catheterized specimens. The initial blood examination showed a moderate anemia; red count 3,800,000 of the hypochromic type, the hemoglobin being 55 per cent (Sahli); white blood count, 8,800. The platelets were normal. The differential count showed 87 per cent polymorphonuclears, 8 per cent lymphocytes, 4 per cent large mononuclears and 1 per cent eosinophiles. A few abnormal cells were later noted in the blood smear which were regarded as myelocytes. Stools were negative. Blood chemistry showed 38 mg. N. P. N. Icteric index was 6. On September 30, 1932, a basal metabolism test showed plus 53 per cent. On October 4, 1932, this was repeated and showed the same result. This subsequently dropped to 35 per cent after the administration of Lugol's solution.

There was considerable discussion on the wards as to the nature of the mass which was felt. The chief difficulty experienced was in differentiating as to whether it was the spleen or was associated with the kidney. A flat abdominal plate on September 24, 1932, showed the right kidney outline was visible, somewhat elongated and low. There was a large mass in the left side, extending to the level of the iliac crest, through which the psoas muscle or kidney could be delineated. There was no evidence of calculi in the urinary tract. The liver appeared enlarged and its edge was low. There were apparently some calcified bodies overlying the iliac crest on the right which might be due to gallstones. There was also evidence of a congenital rib attached to the left transverse process of the first lumbar vertebra. A roent-

genogram of the chest on September 26, 1932, revealed diminished radiance at both apices with fine mottling in the first interspace anteriorly on the right and first and second interspaces on the left; there were numerous small calcified nodules within these areas of mottling. There was also thickening of the descending bronchial trees with slight mottling just above both diaphragms. Both sides of the diaphragm were sharply defined. The right costophrenic angle was shallow (question of thickened pleura); the left was clear. The hilus regions were definitely increased in width and density, especially on the left, and contained numerous calcified shadows. The trachea was deviated to the right.

The first step in the attempt to determine the origin of the mass was a uretero-pyelographic examination resulting in the following report: Both kidney outlines are visible. The right kidney is of about normal size, somewhat low and appears to be rotated; the left is long, narrow and its lower edge lies at the level of the iliac crest. The right pelvis is of the bifid type. The infundibula are elongated. Other than this, the pelvis and calyces show no abnormalities. The upper portion of the ureter shows no abnormalities. The left pelvis is fairly well filled, but shows apparent pressure at the lower portion. The infundibula and calyces are poorly filled. The upper portion of the ureter appears to be displaced inward and the kidney appears somewhat rotated. The lower portions of the ureters cannot be visualized. On September 9, the barium enema was reported as follows: There is no evidence of delay, obstruction or gross irregularity. The descending colon shows a lack of haustral markings. The splenic flexure is very low, lying at the level of the iliac crest In the lateral view, there is apparent pressure in the region of the splenic flexure just anterior to the anterior borders of the lumbar vertebrae (at the level of the fourth lumbar vertebra).

The patient was then given 3 injections of thorotrast of 25 c.c. each at forty-eight hour intervals. On October 11, twenty-four hours after the third injection, a roentgen examination of the upper abdomen revealed the following: The liver and spleen are densely outlined and homogeneous in density. The liver is enlarged and its lower border is blunted, lying about ½ inch below the level of the crest of the ilium. There are numerous stones in the gallbladder. The spleen is tremendously enlarged and its lower edge lies about 1 inch below the level of the crest of the ilium. The right kidney outline is visible; the left is partially obscured by the shadow of the spleen (see Fig. 9).

She was discharged with the tentative diagnosis of chronic myeloid leukemia, aleukemic type, splenomegaly and cholelithiasis.

Fig. 9. Arrows indicate lower edge of enlarged spleen.

Subsequent History. The patient was seen in a follow-up examination on November 17, 1932. She stated that she felt weak and spent most of her time in bed but was able to get up for meals and occasionally to take a short walk outdoors. However, she felt better than she had at the time of entry to the hospital. On physical examination she appeared fairly well (better than on discharge). No glands were felt except in the right axilla and a few pea-sized inguinals. The spleen was palpable at the iliac crest (no definite change in size). The liver edge was sharp and slightly irregular and extended from the right iliac crest across the abdomen to the level of the umbilicus. (The liver has enlarged.) Weight, 112 pounds; red blood cells, 4,410,000; white blood cells, 7,200; platelets, 640,000; reticulocytes, 3.9 per cent; polymorphonuclears, 82 per cent; lymphocytes, 9 per cent; mononuclears, 3 per cent; eosinophiles, 2 per cent; basophiles, 2 per cent; myeloblasts, 2 per cent. The patient was again seen on June 9, 1933, by the radiologist to whom she

stated that she had gained weight and was feeling fairly well. She was not troubled by any gastrointestinal disturbances. A roentgenogram of her abdomen was taken at this time which showed the liver and spleen well outlined, with a homogeneous density, although the spleen did not appear to be as dense as previously.

Case III. B. P., Jewish female, white, married, aged forty-eight, entered the Beth Israel Hospital on August 9, 1931, complaining of ease of fatigue, weakness and loss of 25 pounds

Fig. 10. Chronic myelogenous leukemia. Liver and spleen enlarged. Homogeneous density.

in weight during the past year. For several months she has noticed the development of a hard mass on the left side of the abdomen unassociated with any symptoms.

Family history and past history are negative.

Physical Examination. Abdomen was full and rounded and the entire left half was occupied by a huge, firm, smooth, non-tender, nonpulsating mass extending from the left costal margin down to the pelvis, presumably spleen. Liver could be felt 2 fingerbreadths below the right costal margin, firm and non-tender. There were no dilated superficial abdominal veins or any signs of free fluid, and there was no peripheral adenopathy other than a few small firm movable inguinal glands.

Laboratory Findings. The blood cytology showed a red blood count of 4,260,000 with 58 per cent hemoglobin (Sahli); white blood count, 208,000. The smear showed the differential count: 62 per cent polymorphonuclears, 3 per cent lymphocytes, 30 per cent myelocytes and 3 per cent myeloblasts. The blood chemistry showed a normal non-protein nitrogen, creatinin and cholesterol. Uric acid findings were 3.4 and 3.7. mg. The basal metabolic rate was plus 51 per cent, dropping slightly and gradually to plus 41 per cent following administration of Lugol's solution and finally shortly before discharge was plus 21 per cent. A bone marrow biopsy was reported as chronic myelogenous leukemia.

During her stay in the hospital the patient received a course of roentgen irradiation and this was followed by progressive decrease of the white count to 25,500. She was given reduced iron 1 gram 6 times daily to combat a progressive anemia. She was finally discharged on September 11 as improved. She was followed in the Out-Patient Department and then readmitted on September 22, 1932. During this year she was fairly well except for weakness. On examination the abdomen was found to be markedly protuberant. The liver and spleen were greatly enlarged.

Roentgen examination of the abdomen made twenty-four hours after the last of 3 injections of 25 c.c. of thorotrast showed the liver and spleen densely outlined. The liver was regular in contour and of homogeneous density. The spleen was tremendously enlarged measuring about 29 cm. long and about 24 cm. in its widest diameter (see Fig. 10).

COMMENT ON CASES

In Case I, we find the situation, so often encountered, of a small adenocarcinoma at the rectosigmoidal junction with hepatic metastastes. There is no correlation between the size and appearance of the local lesion and the presence or absence of metastases. Although in this case the hepatic involvement was clinically demonstrable, there are many occasions when a palpable liver is not present and yet early metastatic involvement has already taken place. The decision in regard to the course of action may be considerably altered by the presence or absence of such metastases.

Case II proved the value of visualization in delineating a mass in the left side of the abdomen, the origin of which was the source of considerable doubt and discussion. A large number of the attending

staff saw this patient and the mass was regarded by most of the staff as a nephrogenous tumor. With the aid of the thorium dioxide it proved to be spleen and on reexamination of the blood a diagnosis of aleukemic myelosis was then made.

Case III represents the hepatosplenomegaly associated with the classical type of myelogenous leukemia. The spleen and liver are easily visible and their relative sizes may be compared. Any progressive or retrogressive changes associated either with advance of the disease or the result of effective therapy can be followed from time to time. Thus, we have seen the spleen retrogress to an amazing degree in leukemia. This is applicable also to metastatic neoplastic lesions although in these cases the observations are usually limited to watching the progressive increase in size and spread of the growth.

CONCLUSIONS

By means of the intravenous injection of colloidal thorium dioxide (thorotrast) the liver and spleen can be visualized. This visualization is conditioned by the fact that the thorium dioxide is taken up by the reticulo-endothelial tissue. Other portions of the reticulo-endothelial system as the bone marrow, some lymph glands and adrenals can be visualized in rabbits following larger doses. As far as known the functions of the endothelial system are not disturbed by the presence of the thorotrast, at least for a period of two to three years. Studies of 25 rabbits reveal a marked tolerance to many times the visibility dose, even if given over a long period of time. Tissue studies have failed to indicate any significant pathological changes. The average human dosage is about 1 c.c. per kg. diluted with saline or glucose or it may be given undiluted. In rabbits the visualization dose is somewhat larger, being 1.5 to 1.75 c.c. With minute doses frequently repeated over a long period of time, we observed that the liver first became demonstrable.

There are practically no immediate reactions. The question of remote effects is still "sub judice," elimination is slow, some thorium remaining in the tissues after a few years.

Clinically it is indicated as an agent useful in establishing a diagnosis of a large number of conditions of the liver and spleen and may be of value in a great many other intra-abdominal conditions. It may also obviate exploratory surgery by establishing the presence of hepatic metastases.

Until this procedure is proved innocuous, we believe its use should be restricted to patients of the middle or older age groups or in cases where definite malignancy is found and the pertinent question of metastases is involved. There are a great many problems still to be solved and it opens up a new field for experimental work in clinical medicine and roentgenology.

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AN IMPROVED APPARATUS FOR ENCEPHALOGRAPHY ADAPTABLE TO VENTRICULOGRAPHY*†

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VENTRICULOGRAPHY and encephalography have become increasingly important aids in neurologic diagnosis since their introduction by Dandy[4,5] in 1919. Both procedures depend upon the replacement of cerebrospinal fluid by air and subsequent cranial roentgenography. In all other respects the procedures are radically different. Ventriculography is performed in cases of suspected intracranial neoplasm often with increased intracranial pressure; the air (or other gas) is introduced directly into the ventricles through one or more trephine holes and the ventricular system alone is outlined; finally, the entire procedure is done with the patient recumbent or nearly so. Encephalography, on the other hand, is usually employed to demonstrate atrophic cerebral changes and is not often attempted in the presence of increased intracranial pressure; the replacement of spinal fluid by air is accomplished by lumbar puncture and as a result both ventricular and subarachnoid intracranial spaces are outlined, and the entire procedure should be carried out with the patient in the sitting position. The relative merits of these two diagnostic methods have been subject to much discussion, and it would appear that encephalography is becoming more popular in recent years. It is our purpose in this communication to present an apparatus adaptable to either method, of value to both and especially helpful in encephalography.

It is obvious that such an apparatus, to be of service, should fulfill several requirements. It should be adjustable to both recumbent and erect positions. It should serve to facilitate the management of an anesthetized patient and thereby increase the ease and rapidity of the air injection. It should minimize the manipulation of the patient, thereby facilitating roentgenographic technique and at the same time minimizing the patient's subsequent reactions. The entire procedure should increase the reliability of the resultant roentgenograms.

The use of complete anesthesia during both ventriculography, and encephalography is becoming increasingly prevalent. Straining with subsequent increase in intracranial pressure is prevented; the analgesia is an immense relief to both operator and patient, and the various postures of the head may be more readily maintained during roentgenography. Furthermore, the severity of the patient's reaction to the introduction of air is distinctly diminished.[16]

In most clinics, encephalography is performed with the patient in the erect sitting position.[1,13,14] One author advocates an angle of 45 degrees,[3] while in another clinic the air is introduced in the sitting position but roentgenograms are made while the patient is recumbent.[11] There are many reasons for the maintenance of the erect sitting position throughout the entire procedure. In the first place, air will more readily and completely replace the spinal fluid if the patient is sitting erect. Secondly, air so introduced tends to fill equally well the subarachnoid spaces on both sides of the falx. The patient must be maintained in a sitting position during the air injection and until all the roentgenograms have been made. Maintenance of the sitting posture throughout the entire procedure prevents any asymmetrical accumulations of air in the uppermost intracranial spaces. Such accumulations are often erroneously diagnosed as evidence of cerebral atrophy (Fig.

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Fig. 1. Encephalogram demonstrating the results that may be obtained if the patient's head is not maintained erect during encephalography. Note the pocket of air, *A*, simulating cortical atrophy and the shift of the falx, *B*, away from this pocket.

1). As many encephalograms are done in order to ascertain the degree and location of cerebral atrophy, it is of the utmost importance to maintain the normal laterality of the intracranial spaces.

Occasions arise, however, when it is advantageous to change from the sitting to the recumbent position. In suspected temporal lobe tumors, it is desirable to demonstrate the temporal horns. These structures do not always show when the entire encephalographic procedure is carried out in the erect position, although, careful anteroposterior tilting of the head during air injection usually fills the temporal horns. However, when it is essential to demonstrate these structures, exposures may be made in the horizontal position after the usual films are taken with the patient erect; some manipulation of the head is necessary to insure adequate filling. In order to demonstrate the occipital horns, posteroanterior exposures may be made with the patient in the prone (face down) position.

Some authors stress the importance of rotating the head during air injection, employing lateral flexion also. However, in our experience, lateral flexion sometimes produces unequal distribution of air on either side of the falx. Slow, continuous anteroposterior flexion and extension of the head during replacement of spinal fluid by air seems quite adequate and predisposes to equilateral distribution. The effect of manipulation of the head (intentional or otherwise) is to increase the severity of the post-encephalographic reactions. After the spinal fluid has been replaced by a gas, the brain must be in a relatively "dry" box and therefore more liable to the action of gravity than when supported by its normal spinal fluid cushion. Conse-

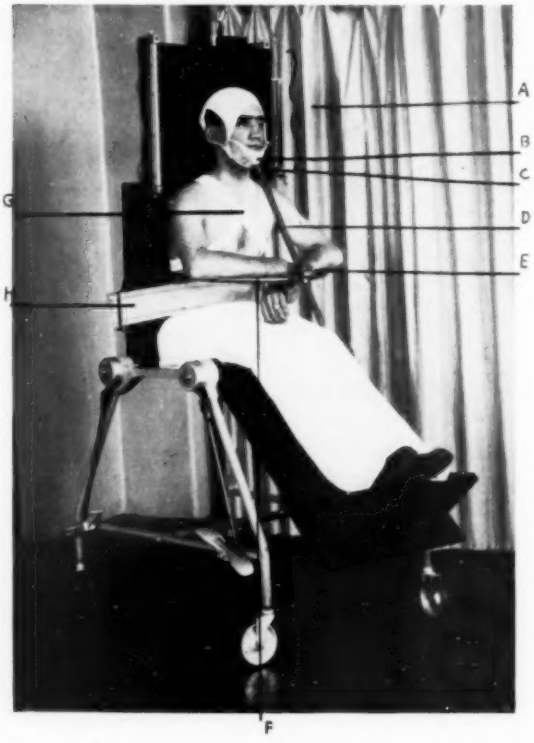

Fig. 2. The apparatus in position for encephalography or anteroposterior roentgenography. *A*, Potter-Bucky diaphragm; *B*, aluminum chin rest; *C*, ball and socket joint; *D*, rod supporting chin rest; *E*, lock joint allowing of movement of chin rest in any desired position; *F*, semicircular removable supporting rod for chin rest; *G*, chest straps; *H*, abdominal band.

quently, any manipulation of the head results in massage and distortion of the soft heavy brain mass against the walls of the cranium. Patients subjected to a minimum of cranial manipulation do not appear to react as severely to encephalography as those subjected to extensive manipulation and to transfer from place to place.[17]

The apparatus which has been devised to meet these requirements is a refinement of the encephalographic chair as originally used in the Boston Psychopathic Hospital.[12] Other chairs[2,15] for similar purposes are in use elsewhere, but we believe that this chair embodies certain new and advantageous features.

It consists of a sturdy wooden table, hinged in three sections, the middle section being mounted on a strong steel frame and this in turn upon wheels equipped with pedal locks. The two lateral sections are hinged so as to swing up or down from the rigid mid-section, thus forming either chair or table as desired (Figs. 2 and 3). They are then locked in position at any desired angle from the horizontal by means of foot pedals. The lower section is equipped with a sliding removable foot-rest which may be adjusted to the patient's leg length, and the upper section is pierced by a large window through which lumbar puncture is performed (Fig. 4). The patient is secured in position by a wide abdominal and two narrow shoulder straps. A new feature is an aluminum chin rest, mounted on a vertical bar slung on a semicircular rod encircling the patient, which gives support for the head.* This provides for both manipulation of the head and its immobilization in any position during roentgenography (Figs. 2 and 5). Another addition is the attachment of the Potter-Bucky diaphragm to a supporting rod on the back of the chair in such fashion as to allow of its movement in any plane.

We suggest the following procedure for encephalography, although the various other methods in use elsewhere may be employed. The use of anesthesia is strongly recommended and the non-volatile anesthetics have been found to be most useful.[16] Ether is to be avoided because of the resultant increase of intracranial pressure. Anesthesia is induced while the patient lies recumbent upon the apparatus extended in the form of a table (Fig. 3). The abdominal and shoulder straps are fastened and the supporting rod with the chin rest is inserted into the sockets. The apparatus is then elevated to form a chair and the patient is adjusted for lumbar puncture. Our apparatus has been found to provide a firm but comfortable restraint to the anesthetized patient. It is obvious that maintenance in the erect sitting position of a

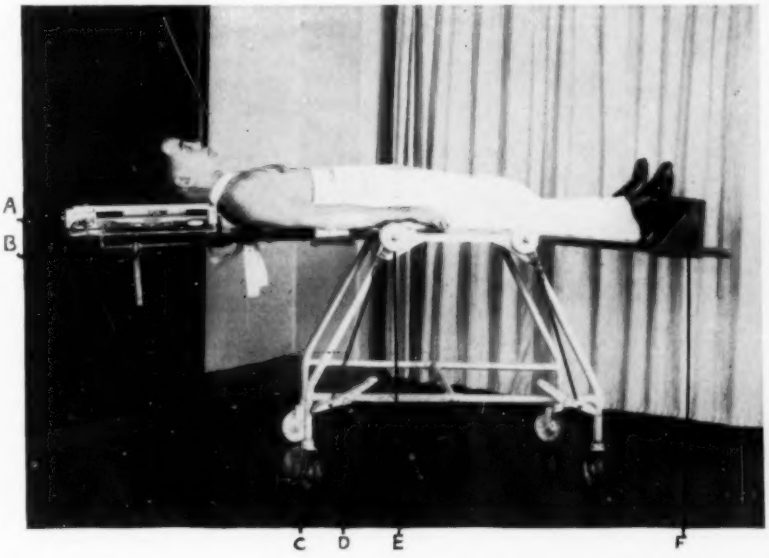

Fig. 3. The apparatus extended in the horizontal position for recumbent roentgenography, ventriculography, induction of anesthesia or for use as a litter. *A*, Potter-Bucky diaphragm; *B*, supporting rod for diaphragm; *C*, pedal locks on 5 inch wheels; *D*, foot pedal operating ratchet, *E*, so that back and leg sections may be raised, lowered and locked at any desired angle; *F*, adjustable foot rest.

* This device was suggested by Dr. S. S. Hanflig, one of the original authors of the Epstein-Hanflig encephalography chair.

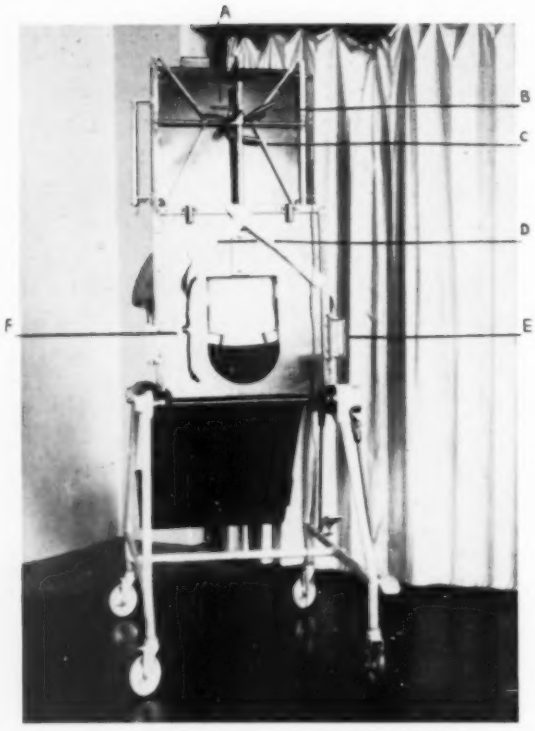

Fig. 4. Posterior view of apparatus with patient in position for lumbar puncture. Lock joints for Potter-Bucky diaphragm regulating *A*, anteroposterior, *B*, vertical and right and left rotatory, *C*, anteroposterior rotatory movements. *D*, buckles for chest straps; *E*, tightening lock for abdominal band; *F*, window through which lumbar punctures are performed.

completely relaxed patient is well nigh impossible without some such apparatus. It also adds materially to the comfort and sense of security of patients under light morphine and scopolamine narcosis.

If a previous lumbar puncture has not been performed, the initial pressure may be ascertained by performing a lumbar puncture in the left lateral recumbent position while the chair is extended in table form. Subsequently, the patient may be rotated carefully to the supine position so that the lumbar needle protrudes through the aperture in the back of the chair. The table is then elevated to form a chair and the procedure is continued with the patient sitting erect. It is always our practice, prior to encephalography, to ascertain the spinal fluid pressure with the patient in the recumbent position. In these cases, the lumbar puncture for encephalography is performed with the patient in the sitting position.

Any method of spinal fluid replacement may be used with the apparatus. The double needle constant replacement method is recommended.[18] The essential points are to observe that the spinal fluid pressure progressively falls during the procedure and to attempt to replace all available fluid by air. Enough gas is then introduced to maintain a final sitting lumbar pressure at a level about equal to the initial recumbent lumbar pressure. Not only may more air be introduced by this method with the result that the roentgenograms show more detail but also the patient's reaction is reduced to a minimum.[17] Encephalograms (Figs. 6 and 7) resulting from the use of this apparatus compare favorably with the excellent studies of Davidoff and Dyke.[7,8,9,10]

By manipulation of the chin support,

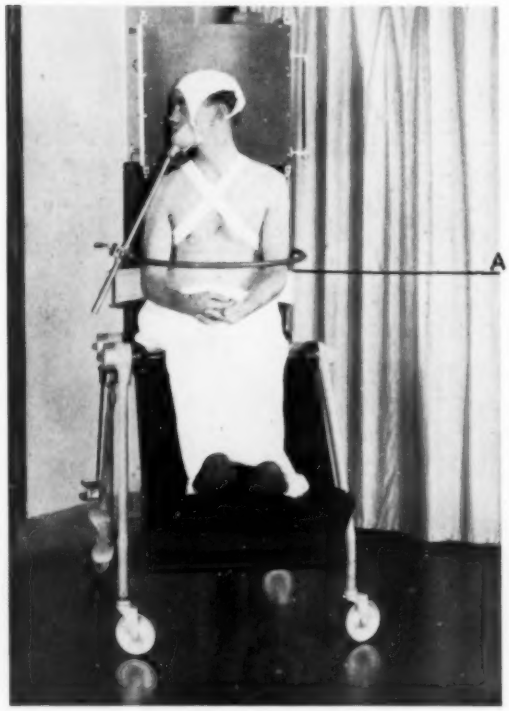

Fig. 5. The apparatus in position for right lateral roentgenographic exposure. Note the chin rest and its support have been swung around an arc of 90° on the semicircular supporting rod. *A* indicates socket into which the semicircular supporting rod fits.

any desired rotation, flexion and extension of the head can be easily and evenly obtained. As noted above, we find that slow anteroposterior movement of the head is the most advantageous maneuver.

Roentgenograms are made as soon as possible after completion of the air injection. The procedure may be somewhat simplified by bringing a portable roentgen machine to the patient, thereby facilitating the making of roentgenograms at the bedside or in the operating room with a minimum of manipulation of the Patient. Otherwise, the patient, sitting erect, is wheeled to an immobile roentgen machine, or the entire procedure may be performed in the roentgen room. If the latter is done, the attachment of the Potter-Bucky diaphragm to the chair makes possible roentgen exposures at any time during the air injection after the manner of Davidoff and Dyke.[6] The usual exposures consist of three sets of stereoscopic views all taken in the erect position: namely, right and left lateral and anteroposterior. Adjustment of the chin rest along its supporting arc facilitates immobility of the head during roentgenography (Figs. 2 and 5). The diaphragm may also be adjusted to the position of the patient's head. It is not necessary to remove the chin rest, which, being aluminum, casts but little shadow and that only over the relatively unimportant mandible. Any other desired exposures may be made by reciprocal adjustment of the apparatus and the roentgen tube.

For ventriculography, this apparatus may be used as an operating table (Fig. 3) and the air injection is carried out with the patient in the recumbent (supine) position. The roentgenograms are then made in the four usual recumbent positions: prone, supine, right and left lateral, as well as any indicated variations of these.

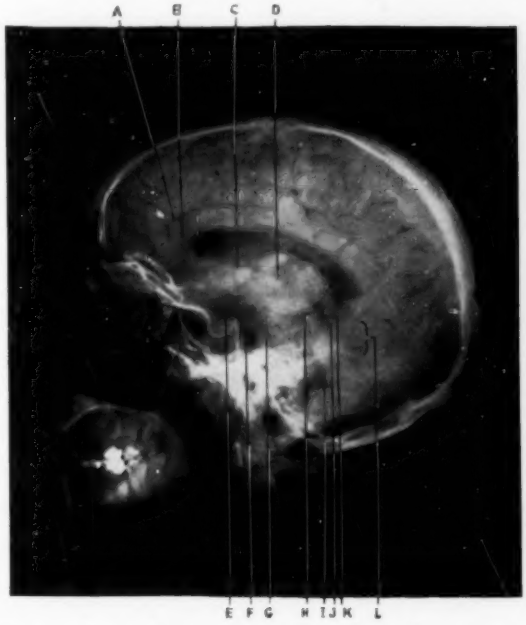

Fig. 7. Lateral encephalogram illustrating some of the structures demonstrated by the recommended encephalographic procedure. *A*, cingulate sulcus, *B*, corpus callosum; *C*, foramen of Monro; *D*, massa intermedia; *E*, optic nerve; *F*, pons; *G*, middle cerebral artery; *H*, cisterna ambiens; *I*, fourth ventricle; *J*, *K*, superior and inferior colliculi; *L*, vermis.

Fig. 6. Encephalogram demonstrating the results obtained by maintaining the patient in a sitting position and by tilting the head slowly forward and back during the injection of air. *A*, falx; *B*, corpus callosum; *C*, septum pellucidum; *D*, thalamus; *E*, Sylvian fissure; *F*, island of Ryle; *G*, anterior and mid-lateral ventricles; *H*, third ventricle; *I*, hippocampus. Note the even equilateral distribution of the air.

If desired, the Potter-Bucky diaphragm may be removed from the chair and ventriculograms or other skull roentgenograms may be made on the operating table or in bed, with the aid of a portable roentgen machine. The chair, of course, may be used without the Potter-Bucky attachment and may be wheeled to the roentgen room equipped with the usual vertical Potter-Bucky stand. The entire apparatus may be used as chair or litter in transferring the patient to and from the roentgen room.

SUMMARY

We present an apparatus adaptable to either encephalography or ventriculography, which is especially useful for encephalography. It has been found to provide firm and comfortable restraint to patients under narcosis. It thus serves as an aid in the manipulation of the patient during the entire procedure. The use of this apparatus would appear to minimize the patient's reaction and also to increase the reliability of the roentgenograms.

The apparatus is sturdy, easy to move and to manipulate. A new feature consists of a chin rest by means of which the patient's head may be easily manipulated and immobilized in any desired position for roentgenography. Another addition is the attachment of the Potter-Bucky diaphragm to the back of the chair in such fashion that the Potter-Bucky may be manipulated in any plane. The apparatus may be used in conjunction with a portable roentgen machine.

The theory and technique of encephalography are briefly discussed and a procedure for encephalography is suggested.

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MULTIPLE BONE TUMORS WITH UNUSUAL DIAGNOSTIC AND THERAPEUTIC CHARACTERISTICS*

REPORT OF CASE

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ANYONE who has been interested in bone pathology over a period of years must be impressed with the difficulty of the diagnosis of the lesions. The difficulty in diagnosis applies not only to the roentgen but also to the microscopical examination of the tissues. Many of us have sent microscopical slides of a bone lesion to many of our leading pathologists and have received in return great variations in the diagnosis. This statement is not made to disparage the value or the competency of these men or their opinions, but rather to show how difficult it is to arrive at an exact diagnosis.

We have been interested in a patient, for a period of three years, who has developed numerous bone lesions. This patient has been closely examined by many members of our hospital staff, and on two different occasions biopsies have been made. The first one in February, 1932, from the femur, and the second in January, 1934, from the humerus. The microscopical findings were entirely different at each examination.

The patient, a well-nourished white male, aged fifty, was admitted to the hospital on the service of Dr. Samuel C. Plummer, on October 6, 1931, for treatment. Upon interrogation, the following chief complaints were elicited: inability to use the right lower extremity for the past six days; chronic arthritis of all of the joints of both upper and lower extremities of two years' duration.

Present Illness. The patient's arthritis has been present for two years, first appearing in the left ankle and the left knee. These joints were greatly swollen. The pain and discomfort were more pronounced in the morning, and oftentimes it would take a few hours before the pain subsided permitting the joints to be used. Later on, pain developed in both shoulder joints, hands and right leg. It was not uncommon for some of the joints to show subjective improvement as other joints were becoming painful and inflamed. During the past year there has been a marked improvement, and there has been no pain in the arms, hands or legs. At no time during the acute exacerbations of the arthritic seizures did the patient have fever, and he was able to continue his daily labor.

The patient fell and sustained an injury to his right hip on July 19, 1931. The right hip became very painful and he was compelled to use crutches to aid him in walking. At times, the pain would subside, permitting him to walk without the assistance of the crutches or of a cane.

On October 1, 1931, while walking across the floor, during a visit to his son's home, the patient's right leg collapsed under him, throwing him to the floor, accompanied by a loud cracking sound, as if a "large bone had broken." His right leg would not sustain his weight, but with the aid of crutches he was able to go down stairs and enter his automobile. He experienced very little pain and intended to return to his home. His son persuaded him to seek medical attention at once and to submit to a roentgenological examination. He visited the doctor's office and experienced no discomfort other than that caused by the return to the use of crutches. Within a few hours after the injury, roentgenograms were made at the doctor's office and revealed a fracture in the proximal third of the right femur. The limb was splinted and he returned to his home. The next day the physician had consultation with a specialist at the patient's home. After examination, the specialist advised immediate amputation of the right lower extremity at the hip joint. The patient refused to give his consent to the operation, and came to the office of Dr. Plummer seeking professional services and advice. At this time, the patient experiences no pain in the region of the right hip. After he retires in the evening, or assumes a recumbent position, the anterior surface of the right tibia is somewhat painful.

* Read at the Thirty-fifth Annual Meeting, American Roentgen Ray Society, Pittsburgh, Pa., Sept. 25–28, 1934.

Past Medical History. Mumps in childhood, and a moderately severe attack of influenza in 1917. Otherwise essentially negative with the exception of those complaints made above under present illness, namely, chronic arthritis for the past two years, and fracture of the right femur. No operations. Head: Occasional headaches associated with constipation. Ears: Hearing normal. Negative for earache or discharge. Nose: Negative for discharge or obstruction. Mouth: The teeth that are present are in very poor condition. The majority of the teeth were extracted within the past year, as the suspected focus for the chronic arthritic infection. The tonsils were negative and there is no history of any sore throats. Cardiorespiratory: Negative. No history of cardiac disease. No dependent edema. No history of any pulmonary disease, other than the influenzal attack noted above. Gastrointestinal: Excellent appetite. Gastrointestinal upsets never experienced. Bowels regular, and cathartics are used only occasionally. No history of bloody or tarry stools. Genitourinary: No burning, hematuria or dysuria. Nocturia once or twice. No difficulty with the act of urination. Gonorrheal infection nine years ago, treated. Syphilis denied. Neuromuscular: No dizziness. Walks well after dark.

Family History. Father and mother both dead. Cause unknown other than senility. Negative family history for cardio-renal-vascular disease, mental disease, tuberculosis, or malignant new growth.

Social History. Gateman at the LaSalle Street Station for the past eleven years. Married twenty-six years. Divorced from wife ten years ago. The wife had two pregnancies, first, a normal male child, living and well at the present time. Second, still birth, seven months.

Physical Examination. A white adult male about fifty years of age, well nourished and appears to be in excellent health lying comfortably in bed. Eyes: Conjunctiva negative. Pupils react to light and accommodation. Mouth: All of upper teeth are absent due to extraction, and the majority of the lower teeth are absent. Those lower teeth that are present are in very poor condition. Fauces negative. No evidence of any inflammation about the tonsils. Chest: Lungs normally resonant, expansion good and equal on both sides. No altered fremitus, no râles. Breath sounds normal. Heart not enlarged, no murmurs or arrhythmia. Abdomen: Moderately flaccid. No masses could be palpated or areas of tenderness elicited. No evidence of any fluid present. The liver, spleen and kidneys could not be palpated. Extremities: Patient is unable to move right leg which is immobilized with sand bags. No pain could be elicited upon the movement of any of the joints in any of the other extremities. No limitation of movement of any of the joints of the upper extremities or of the left lower extremity. Reflexes: Patellar and plantar reflexes active in left leg. Biceps are active and equal on both sides. Genitalia: Negative to external examination.

Impression. Pathologic fracture of the right femur of undetermined etiology.

At no time during the patient's hospitalization was there an alteration from the normal in the temperature, pulse or respiration. The blood pressure was within normal limits. The urine was negative except for the presence of a few leukocytes. The blood count was as follows: red cells, 4,350,000; white cells, 10,200; hemoglobin, 78 per cent; blood Wassermann and Kahn tests negative.

Roentgen Findings. Roentgen examination of the proximal portion of the right femur was made on October 7, 1931. The roentgenograms revealed a large, somewhat circumscribed area, cystic in appearance, as well as a fracture, at the level of the lesser trochanter. The line of fracture extended upward and outward through the rarefied area and was diagnosed as a pathologic fracture. The fragments were in excellent position. We were of the opinion that the rarefied area was the result of a large cyst. The cortex was thinned but intact and the lesion was quite sharply circumscribed. Inasmuch as the lesion appeared unusual, we examined other bones of the body including the pelvis, lumbar spine, chest, skull and the opposite femur. The additional examinations made revealed nothing pathological. The lungs and ribs were negative.

Additional roentgen studies were made of the proximal portion of the right femur on October 10, 1931, at various angles. In one of the films we thought there was invasion of the cortex. This fact presented the possibility that the lesion might be due to a malignant tumor, but we were unable to state whether it was the primary or a secondary lesion.

Additional laboratory examinations were made and the blood chemistry was as follows:

	mg.
Urea	9.3
Non-protein nitrogen	30.0
Uric acid	4.6
Sugar	94.0
Calcium	9.7
Inorganic phosphorus	3.2
Alkali reserve	39.4

The inorganic phosphorus in the urine was 0.46 mg., urea 0.790 (2,300 c.c. twenty-four hour specimen).

Differential Diagnosis. The possibility of the lesion with the pathologic fracture having a cystic origin had to be considered. The fact that we thought we could demonstrate invasion of the cortex made a possibility that we were dealing with a malignant tumor which could not be ignored.

Throughout our studies of this lesion, the work of Ballin and Morse was quite prominent in our minds, and possibly we were trying too hard to classify this lesion under the parathyroid group. Although the results of the blood chemistry examination presented no abnormal findings, we knew that Dr. Ballin stated that there is not always an elevation of the blood calcium in hyperparathyroidism with bone changes.

Fig. 1. Right femur, before roentgen therapy.

Fig. 2. Right femur, after roentgen therapy.

Many consultants, including Drs. A. R. Elliott, L. E. Schmidt, and E. W. Ryerson, made an examination of the patient and the roentgenograms. All consultants agreed as to the difficulty of classification and diagnosis of the lesion, but thought that the femoral lesion appeared cystic.

At the conclusion of the various consultations roentgen therapy to the lesion was advised.

Treatment. High voltage roentgen therapy was administered to the proximal third of the right femur starting October 12, 1931; a total of ten treatments was given, using three portals of entry (anterior, posterior and lateral). A grand total of 2,185 r was given through 1 mm. of copper plus 1 mm. of aluminum, 200 kv. p. The series of treatments ended on November 21, 1931.

Roentgenograms made two months after the treatments showed no further progress of the disease. The texture of the bone improved but did not regenerate. The pain was definitely controlled.

Fig. 3. Right jaw, before roentgen therapy.

A biopsy on the lesion of the right femur was performed by Dr. Plummer on February 4, 1932. A large block of bone was removed from the upper third of the right femur through the greater trochanter. The pathological report, made by our pathologist, Dr. Edwin Hirsch, on the material obtained at biopsy is as follows:

This piece of bone from the greater trochanter of the right femur is 4×3×2 cm. thick. The cortex is curved convexly and rough with adherent muscular and fibrous tissue. The bone has been cut to a depth of 2 cm. The cortex is thin but hard with calcium and the spongy bone beneath is coarsely porous and has wide marrow spaces filled with fat tissue. The bone trabeculae are small and on the surfaces where they are cut, they are like sharp spines and hard. The marrow spaces do not contain a white or gray tumor-like tissue.

Histology: The histologic preparations are made from the periphery toward the center of a wedge of bone excised from the trochanter of the femur. The cortex is narrow and the bone trabeculae extending from the cortex are also narrow. Their osteogenic membranes are present in but a variable degree. Some of the bone trabeculae are narrow and have lost their osteogenic membranes or this is still present as a narrow layer of atrophic cells. The marrow spaces are wide and are filled with fatty areolar tissue and edematous fibrous tissue. There are only a few marrow spaces with masses of hematopoietic cells.

Diagnosis: Aseptic necrosis of the proximal third of the right femur.

Dr. George W. Hall examined the patient from a neurological standpoint on February 17, 1932, and found nothing abnormal. At his suggestion a spinal puncture was made. The pressure was 450 mm. H_2O in the sitting position; 10 c.c. of clear fluid was removed. The results of the laboratory examination made on the spinal fluid obtained is as follows: Wassermann and Kahn were negative, 1 cell per c.mm. The Ross-Jones was faintly positive; Pandy faintly positive.

Although we made several requests for the patient to return to the department, we did not see him again until January 2, 1933, when he presented himself with the following chief complaints: a large mass involving the lower right jaw. The mass was as large as a man's fist and was very hard, and there was considerable pain; inability to use the right lower extremity without the use of crutches. The mass in the lower right jaw was a recent development and upon physical examination and palpation it appeared to be a part of the lower jaw. Movement of the jaw elicited pain but the mass itself was not tender. Roentgenograms of the lower jaw revealed a large homogeneous rarefied area extending well anterior to the angle. The cortex along the inferior surface was intact, except for pathologic fracture with no displacement of the fragments. The lesion in the jaw presented one rather puzzling area along the aveolar border. At this point the cortex was absent, and this made us suspicious of a malignant tumor. From the roentgen findings we were of the opinion that the lesion was due to a cyst or a large adamantine epithelioma. The left femur, skull, pelvis, spine, ribs and chest were again roentgenographed. No important changes were identified, except for a small rarefied area accompanied by a mass in the seventh rib anteriorly on the right side. Roentgenograms of the right femur revealed no evidence of bony union of the fracture. The ends of the fragments were thickened, smooth, and the medullary cavity was not completely closed.

Fig. 4. Right jaw, after roentgen therapy.

Continuation of the roentgen therapy was advised, but we did not admit the patient to the hospital. He was irradiated as an out patient. On January 10, 1933, deep roentgen therapy was administered to the right lower jaw and cervical region, using 200 kv. p. with 0.5 mm. copper plus 3 mm. aluminum. A total of four treatments was administered at monthly intervals. A total of 800 r was given. The mass in the jaw became smaller two weeks after treatment and the pain rapidly subsided. On May 17, 1933, no mass could be palpated externally, and the jaw appeared normal.

At various intervals between May 17 and December 1, 1933, we made inquiries of the patient as to his general condition and with special reference to the right jaw and the right femur. At no time did we obtain any information which led us to believe that there was any evidence of a recurrence of either lesion. However, on January 10, 1934, he was readmitted to the hospital with the following chief complaints: pain and swelling in his left arm, of short duration and no history of recent injury; his right lower jaw he stated "has been restored to normal and is perfectly well." He can use it as well as ever, and on physical examination there is no evidence of swelling present, seems solid and functions normally; inability to use the right lower extremity with an occasional pain in the right hip. Physical examination of the left arm revealed that it was about twice its normal size and was hard on palpation. There was no redness or local heat. Great pain was present in the left elbow, which we believe was probably due to pressure. The patient has definitely lost ground since we last saw him. He presents an anxious facies and has lost about 20 pounds in weight during the last month.

Fig. 6. Left humerus, after roentgen therapy.

Fig. 5. Left humerus, before roentgen therapy.

Laboratory examinations gave the following results: The urine was negative for albumin, sugar, casts, etc., urinary calcium 0.041 gm., phosphorus 0.337 gm.; negative for Bence-Jones bodies. The blood count had decreased since the last examination: red cells 2,050,000, white cells 6,100, hemoglobin 38 per cent. Blood chemistry: urea 12 mg., non-protein nitrogen 30 mg., uric acid 4 mg., inorganic phosphorus 0.37 mg., calcium 10.33 mg.

Another consultation was had with Dr. A. R. Elliott, and upon examination he found considerable fluid in the left chest. The mass in the right lower anterior axillary line (reported above as a mass in the seventh rib) had greatly increased since the last examination. The heart tones were weak, but otherwise normal. There was no evidence of any mass or fluid in the abdomen. The left arm was twice its normal size,

hard, not tender and no evidence of local heat. The patient acknowledged no subjective symptoms relative to the fluid in the chest or the mass involving the seventh rib on the right side.

Roentgenograms of the left humerus showed a large destructive area which apparently was central in origin and had extended through the cortex, periosteum and into the surrounding soft tissues. There were areas of dead bone in the mass, especially along the internal surface. The lesion differed considerably from those present in the jaw and the femur, inasmuch as it was not sharply defined but seemed to invade and extend irregularly upward and downward. There was no sharp line of demarcation between normal and pathologic tissues; although the cortex along the internal surface of the humerus was very thin and expanded, we believed it could still be detected. The greater portion of the mass was made up of a soft substance non-opaque to the roentgen rays, either tumor tissue—cystic or cartilage. Knowledge of the previous lesions in the right lower jaw and the right femur did not prove an aid in making a diagnosis. If we were to examine the roentgenograms of the left humerus, disregarding the knowledge of the previous lesions, we would be inclined to state that the lesion of the left humerus was due to a malignant tumor. We admit that we are at a loss to definitely classify the lesion. We have consulted many of our medical colleagues, members of the pathological, surgical and radiological specialties, and have repeatedly gone over the material with them, but all of our consultants are hesitant about making a definite diagnosis.

Roentgen therapy was administered to the humeral lesion on January 10, 1934, using 200 kv. p., 0.5 mm. copper plus 3 mm. aluminum, 320 r being given over the anterior surface of the tumor, and on January 11, 1934, 280 r over the posterior surface of the tumor. We had knowledge of the sensitiveness of the lesion in the jaw to roentgen therapy, and another interesting point presents itself in the case, due to the very prompt response of the humeral lesion to therapy.

On January 17, 1934, seven days after starting the roentgen therapy to the humeral lesion, the patient returned to the department for further study and biopsy. He was very hesitant about having a biopsy as he stated he had practically no pain and the tumor was very much smaller. Physical examination substantiated his statement, the tumor being one-half its original size. We also roentgenographed the skull, pelvis, left femur, spine, chest, tibiae, and ulnae as in previous examinations. No changes were noted in the skull, pelvis or spine. The tibiae, ulnae, radii and the right humerus showed no evidence of pathology. The chest examination at this time revealed fluid in the lower left chest, and there appeared to be definite thickening of the lower left lobe. The right seventh rib anteriorly showed an area of bone destruction, accompanied by a large, hard, palpable mass, which had increased in size since January, 1933.

On January 18, 1934, Dr. T. L. Hansen performed a biopsy, removing several large masses from the left humerus. The bone lesion was very vascular and soft. The humerus was opened along the outer surface and there was practically no bone remaining. The tumor extended well outward into the soft tissues. Bone could be felt along the internal surface of the humerus. When the masses of tissues were cut, areas which looked like tumors were seen. The sections were sent to our pathologist, Dr. Edwin Hirsch, who called the tumor a myeloma without plasma cells.

Additional roentgen therapy was administered to the humeral lesion, using the same factors as in January, 1934. On February 20, 1934, 450 r was administered to the anterior surface of the left humerus. On February 21, 1934, we gave 256 r to the posterior surface of the left humerus. Again on March 28, 1934, we gave 288 r to the posterior surface of the left humerus and on March 30, 1934, 288 r to the anterior surface of the left humerus, making a total of 1,018 r to the anterior surface of the left humerus, and 864 r to the posterior surface of the left humerus. Within a period of five weeks, during February and March, 1934, we gave a total of 738 r to the right seventh rib anteriorly, using the same factors as for the therapy applied to the humeral lesion.

We have kept the patient under observation, making roentgenographic examinations at intervals of sixty days since last spring. The lesions of the right lower jaw, left humerus and the right seventh rib anteriorly have shown marked improvement and regeneration of osseous tissue. Our last examination of the patient was made on September 11, 1934, and our findings were as follows:

The lesion of the lower jaw continued to show improvement with regeneration of osseous tissue. The line of fracture was still present and there was practically no evidence of osseous union, except along the lower border.

The lesion of the left humerus continued to improve, the fracture had united, and the bone continued to regenerate. There were no subjective symptoms of pain or disability due to impaired movement or use of the mandible or the left humerus. There was no palpable mass present in the lower jaw, and the arm was about normal in size and shape and the muscular strength as demonstrated by the patient's grip and lifting power was within normal limits.

The lesion of the right femur showed practically no roentgen changes since the last examination, although the patient stated he could walk with less difficulty and experienced less pain.

The lesion involving the seventh rib on the right side in the axillary line had progressed since the former examination, and there is now a pathological fracture. The large palpable mass which was present before roentgen therapy, has not recurred.

The left chest was still hazy and the left lung, especially the lower lobe, was definitely infiltrated, probably more so than at the former examination. There is, however, no definite evidence of free fluid in either pleural sac at this time.

DISCUSSION

This case demonstrates very clearly the difficulty of diagnosis of bone lesions by either roentgen ray or microscopical examination. It also demonstrates what can be accomplished by roentgen therapy. It is problematical whether the microscopical interpretations give much aid in the prognosis, or, in other words, whether a lesion is radioresistant or radiosensitive. It also shows quite conclusively that multiple lesions in the same individual may be sensitive and resistant to irradiation.

On reviewing the series of roentgen therapy, one is impressed with the small amount of irradiation necessary to bring about a prompt improvement of three of the bone lesions, whereas, in the lesion of the femur rather large doses of roentgen rays did not lead to an improvement comparable with that obtained in the other lesions. It is possible that too much therapy was administered to the femur, or perhaps the pathology in the femur is a separate and unrelated lesion.

It is quite apparent in some of the roentgenograms that after therapy the bones became quite rarefied, especially in the region of the acetabulum.

Another point of interest is the prompt osseous union of the fragments of the humerus, and the absence of osseous union of the fragments of the mandible and femur, although on physical examination the fragments of the femur and mandible appear to be united. Certainly the fragments of the jaw are fixed, the patient can make all normal movements and has no difficulty in chewing solid foods.

The impression one obtains from the clinical findings is that the patient is suffering from a generalized condition as demonstrated by loss of weight, general weakness and destruction of the blood.

When the patient presented himself for treatment of the lesion of the humerus, we felt quite sure that he was rapidly losing ground and would probably have a rather prompt exitus. It was during this time that the fluid in the chest was discovered. The prompt response following the therapy is quite baffling to all concerned.

DIFFERENTIAL DIAGNOSIS OF ALL LESIONS

The diagnosis of the bone lesions of this patient must of necessity change with the appearance of the multiple lesions. When first seen, the patient had, as far as we could ascertain, only one lesion, viz., in the right femur, which certainly had the appearance of cystic degeneration, through which a pathological fracture had occurred. The fact that the biopsy was called an aseptic necrosis did not alter our original diagnosis. While we felt that the lesion was cystic, the possibility of the lesion being malignant was considered. To differentiate a primary from a metastatic malignancy at this time was unusually difficult, and at the time we were not impressed with the probability of its being due to a metastatic malignancy.

With each succeeding examination we became more interested and also more uncertain as to the nature of the lesion. The lesion of the right lower jaw certainly appeared cystic and, except for one area, the cortex was intact, and we were under the

impression that the lesion of the femur and the jaw were related, but after irradiation and the very prompt response of the jaw lesion, we were again in a quandary. On reviewing the roentgenograms of the chest, we discovered an osteolytic area in the seventh rib on the right side which certainly had characteristics of a metastatic malignancy.

When the patient returned to the roentgen department in January, 1934, he was perfectly comfortable as far as the femur, jaw and rib were concerned. At this time, he was unable to use the left arm, which was swollen about twice its normal size, and was quite hard on palpation. There was no redness or local heat. At physical examination a fracture of the humerus was very apparent. The roentgen examination revealed a large destructive area, probably central in origin, in the upper half of the left humerus. The process extended through and destroyed the cortex and the tumor had extended into the surrounding soft tissues. The roentgenograms were studied very carefully, and frequent consultations were had, and it was the consensus of opinion that the humeral lesion was due to a metastatic malignancy.

The possibility of the lesion being due to a hyperparathyroidism can be definitely ruled out. This is further substantiated by the absence of changes in the blood calcium and phosphorus and absence of changes in the urinary calcium and phosphorus. Furthermore, the succeeding lesions do not have the characteristics of a hyperparathyroidism. The prompt and rapid response of three of the lesions, viz., jaw, rib, and humerus, to irradiation, may be of some importance diagnostically. Everyone is familiar with the response of certain types of myelomata to irradiation, although the improvement is not as lasting. The pathological diagnosis of the section taken at biopsy from the humerus was a myeloma without plasma cells. From all the data we have obtained, it would seem that we are justified in saying these lesions are probably malignant. It would be rather difficult to classify the lesion as multiple myeloma, as in our experience these (multiple myeloma) tumors usually involve the flat bones. We have seen rather extensive lesions in the humerus which were on section diagnosed multiple myeloma but in all instances the skull, ribs, scapulae and vertebrae presented lesions that were typical of the textbook picture of multiple myeloma.

In lieu of the fact that this patient presented clinical and roentgen findings in the chest and lungs, the possibility of a primary lung tumor must be considered. While it seems rather unusual for a patient to have a primary tumor of the lung for over three years and present no clinical or roentgen evidence, we do know from past experience and from the literature that a patient may have a small bronchogenic carcinoma for a long period of time without chest symptoms, which is revealed at post-mortem examination, or the symptoms may be referable to other parts of the body, such as the osseous system. A thorough roentgenographic examination of the individual would reveal numerous osteoclastic changes and on biopsy the diagnosis of metastatic malignancy secondary to a primary lung tumor is made. Therefore, considering these facts, the possibility of a primary lung tumor cannot be dismissed at this time.

SUMMARY

This patient has been observed for three years and has been presented upon several occasions before our hospital staff.

This case certainly teaches us one very important lesson, viz., how difficult it is to classify tumors either by roentgen or microscopical examinations.

It also demonstrates very clearly that sections from different lesions in the same individual may present different histological pictures.

We believe that it is sufficient if the radiologist can tell the clinician whether the lesion is benign or malignant, but, in many instances, unfortunately this is impossible.

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II. ATTEMPT TO PRODUCE PAGET'S DISEASE BY THE USE OF ANTERIOR PITUITARY GROWTH EXTRACT AND PARATHYROID EXTRACT*

CALCIUM DEPOSITS IN THE KIDNEY AND MASSIVE CALCIUM DEPOSITS IN THE BONE MARROW PRODUCED BY THESE EXTRACTS

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DETROIT, MICHIGAN

BECAUSE of our belief that the pituitary and parathyroid glands are the important factors in bone development, we attempted to produce bone lesions, such as occur in Paget's disease, in dogs by injecting anterior pituitary extract and parathyroid extract. The anterior pituitary extract† (phyone) was standardized according to the method of Van Dyke and Wallen-Lawrence. The parathyroid extract† was standardized according to the Hanson method. One cubic centimeter contained 100 Hanson units.

PLAN OF EXPERIMENT

Five adult dogs, not litter mates, selected at random from the public dog pound, were used in the experiment. There were two males and three females in the group, varying in weight from 19 to 59 pounds. One of this group was pregnant. The dogs were segregated into sex groups and were so isolated during the entire period. Because our aim was to produce bone changes, roentgenograms would be permanent records and each animal would serve as its own control.

Due to the rather sudden death of three of the original animals, two additional dogs were started, making a total of seven animals used in the experiment, and four upon which the observations were made. One of the three animals that died received growth hormone alone, but, unfortunately, after thirty days of observation and after having received 30 c.c. of growth hormone, this animal died of bronchopneumonia (distemper). This animal was not replaced. The other two animals died with symptoms of hypercalcemia such as vomiting, anorexia, muscular tremor and weakness. The pregnant animal was one of these. Microscopic sections of the thyroid of this animal showed a very marked exophthalmic goiter. These animals received 100 units of parathyroid extract daily. As shown below, we started the replacements with smaller doses.

Necropsy immediately following death showed no variation from normal except as to exophthalmic goiter in the pregnant dog and acute diffuse nephritis in this animal as well as one of the others. The third animal exhibited only the pneumonic process referred to.

The period of observation varied between 223 and 237 days, the variation being due to the death of the three dogs referred to and the time necessary to secure and begin tabulations on the replacements. The average period of observation was, therefore, 231 days, which was divided arbitrarily into three periods of one hundred, fifty-five and seventy-six days, respectively. During the first period three dogs received daily subcutaneous injections of 1 c.c. of growth hormone and 25 units of parathyroid extract. In the second period of fifty-five days, 1 c.c. of growth hormone and 50 units of parathyroid extract, and in the final period of seventy-six days twice this amount, i.e., 2 c.c. of growth hormone and 100 units of parathyroid extract were so injected. The fourth animal received only the parathyroid extract in similar doses during the three periods.

† The anterior pituitary extract (phyone) was kindly supplied us in generous quantities by Dr. David Klein of The Wilson Laboratories, the parathyroid extract by Dr. H. E. Woodbury of Eli Lilly and Company, and "paroidin" by Dr. E. A. Sharpe of Parke, Davis and Company. We are deeply indebted to these firms for their generosity.

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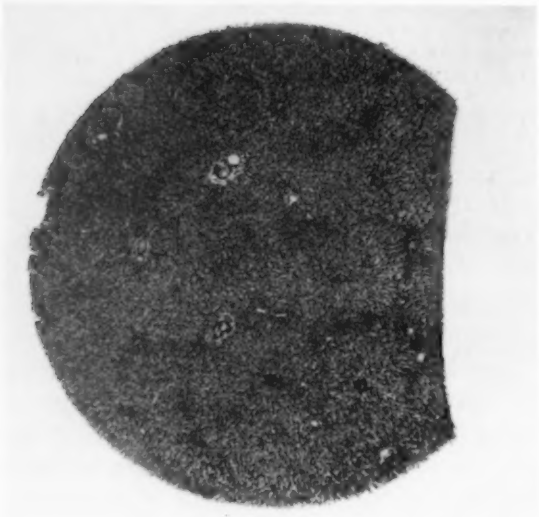

Fig. 1. Dog 1A. Degeneration of the liver cells.

Since the blood phosphatase is increased in Paget's disease and because of Bodansky's work[1] on alimentary glycemia and phosphatase changes, we decided to add glucose to the diet. The diet consisted of meat, bread with gravy, potatoes, carrots, milk, and fish, which seemed adequate in vitamin D content, although no attempt was made to supply the vitamin artificially. Seven ounces of blue label karo syrup (75 per cent glucose) was placed in the daily water ration of 2,000 c.c., making the solution approximately 9 per cent glucose. The addition of the sugar did not interfere with their water intake, which had been somewhat increased in the dogs receiving the combined growth hormone and parathyroid extract. The amount of increase was not measured, but was an obvious one even to our unskilled animal caretaker, who saw that the animals had fresh water. This increased sugar intake was maintained over the last forty days of observation.

Before any biological extract was injected, the animals were roentgenographed, weighed and blood was secured for calcium, phosphorus and phosphatase determinations. These were done in the technical laboratory of Harper Hospital by the same technician, after the standard methods. All of these were tabulated and at intervals of three to four weeks, when it was felt that ample time had elapsed for any significant changes, they were repeated. During the last forty days blood sugars were tabulated with the other data (see context).

At the end of the observation period the dogs were autopsied and gross as well as microscopic sections were studied. It was considered best to kill them by injecting air into the vascular tree. This, however, was found to be a poor method because it was impossible to introduce sufficient air. The first dog was etherized and the remaining three were chloroformed, the latter method proving to be the most satisfactory. Necropsies were performed immediately after death. The protocols follow:

Dog 1A. Female. Etherized. The only gross finding before autopsy was an increased fatty panniculus. Grossly the various organs did not deviate from normal. Microscopically the lung showed acute congestion; the liver showed marked degenerative changes (Fig. 1); the thyroid had the appearance of colloid goiter, and the parathyroids showed marked basophilia (Fig. 2) and were highly vascular. The ovaries showed excessively active ovulation. The bones were grossly normal but microscopically showed massive replacement of bone marrow by calcium deposits (Fig. 3).

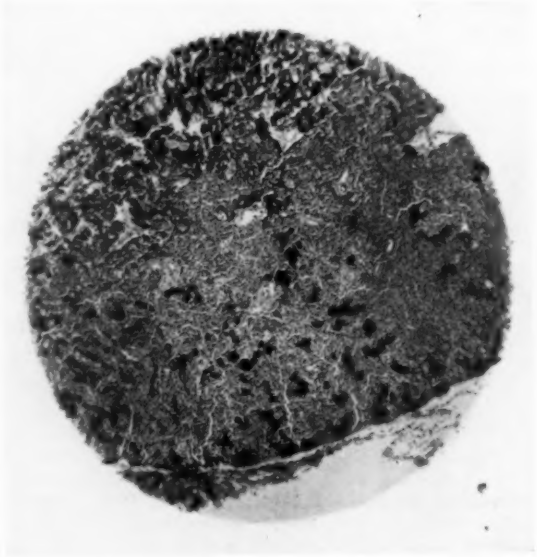

Fig. 2. Dog 1A. Basophilia of parathyroid.

The medulla of the kidney showed calcium deposits (Fig. 4).

This animal received 12,487 units of parathyroid extract combined with 347 c.c. of growth hormone over a period of 223 days.

Dog 2A. Female. Chloroformed. The body showed the same increased fatty panniculus of of Dog 1A. Grossly the individual organs were normal. Microscopically the bone marrow, like Dog 1A, showed a massive replacement of bone marrow by metastatic calcium (Fig. 5). There was also present hyperplasia of the thyroid (Fig. 6)—the parathyroid revealed nothing unusual.

The ovaries exhibited active ovulation with excessively ripe follicles.

This dog received 12,804 units of parathyroid combined with 360 c.c. of growth hormone over a period of 230 days.

Dog 3. Female. Chloroformed. Grossly negative except for a thick panniculus and a greatly enlarged thyroid, each lobe weighing 5 grams. This animal, all during the period of observation, was very irritable and quite difficult to handle. The temper was not unlike that of humans with toxic goiter. Grossly, other than the thyroid the organs were normal. Microscopic bone studies showed a massive replacement of bone marrow by metastatic calcium (Fig. 7).

Microscopically the thyroid was typical of exophthalmic goiter (Fig. 8). The liver showed an acute passive congestion (Fig. 9). The kidneys showed small deposits of calcium with vascular and granular degeneration of the epithelium.

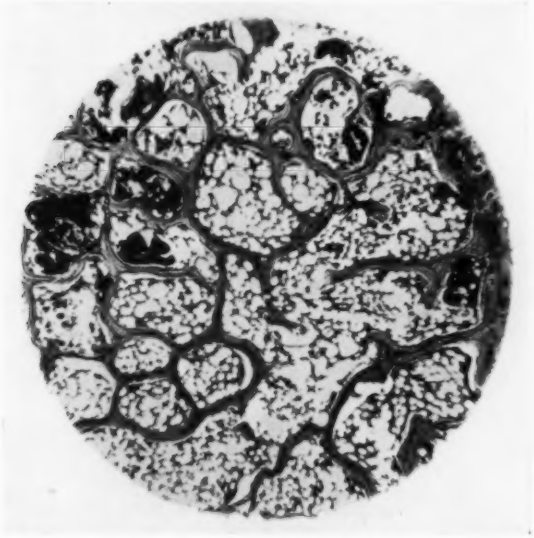

Fig. 3. Bone from Dog 1A, showing marrow replacement by calcium deposits.

Fig. 4. Calcium deposits in medulla of the kidney of Dog 1A (indicated by black areas).

The ovaries exhibited active ovulation with occasional calcium deposit in a follicle (Fig. 10).

This animal received 13,240 units of parathyroid extract and 365 c.c. of growth hormone over a period of 233 days.

Dog 4. Male. Chloroformed. Grossly exhibited a marked increase in fatty panniculus. All organs appeared grossly normal.

Microscopically all organs were normal with the exception of isolated deposits of calcium in the kidney (Fig. 11). Microscopic bone studies were normal. This animal received only parathyroid extract, having 13,503 units over a period of 237 days.

The dogs were weighed at regular intervals and the weights recorded with the other data. The weights increased from 3 to 9 pounds (1.36 to 4.09 kg.), the mean average being 6 pounds (2.72 kg.). Surprisingly enough, the dog (designated as No. 3) having the exophthalmic goiter gained 9 pounds (4.09 kg.), whereas the others gained from 3 to 5 pounds (1.36 to 2.27 kg.). These variations are not deemed significant, since the observations were made through the summer and were terminated early in January when normally dogs take on additional winter weight. These dogs were kept indoors at all times

FIG. 5. Bone marrow of Dog 2A, showing replacement of bone marrow by calcium.

on the roof of the laboratory, but were placed in spaces with open windows and they were exposed to the afternoon sun. This is of importance because of the vitamin D factor in bone development.

The outstanding microscopical findings in the three dogs receiving growth hormone and parathyroid extract were the massive replacement of bone marrow by metastatic calcium deposits.

The microscopical studies of the kidney in three dogs showed calcium deposits, the greatest amount being in the two dogs receiving growth hormone and parathyroid extract. These deposits in the kidney are of interest in regard to hyperparathyroidism associated with nephrolithiasis. There apparently is some causal connection between parathyroid tumors with hyperparathyroidism and the production of nephrolithiasis. Brown[2] recently reviewed the literature on this subject.

The calcium deposits in the kidneys of the three dogs induced by parathyroid extract provides an interesting speculation concerning the etiology of nephrolithiasis. As previously stated, the two dogs receiving both anterior pituitary extract and parathyroid extract showed more calcium deposits than the dog receiving parathyroid extract alone. Then, too, the latter dog did not show the massive replacement of the bone marrow by metastatic calcium as did the other three dogs. Dog 1A on combined growth hormone and parathyroid extract showed the greatest calcium deposits in the kidney. The parathyroids of this animal showed marked basophilia. This would suggest that probably the growth hormone of the pituitary (parathyrotropic hormone?) may be essential or helpful in producing the metabolic calcium changes.

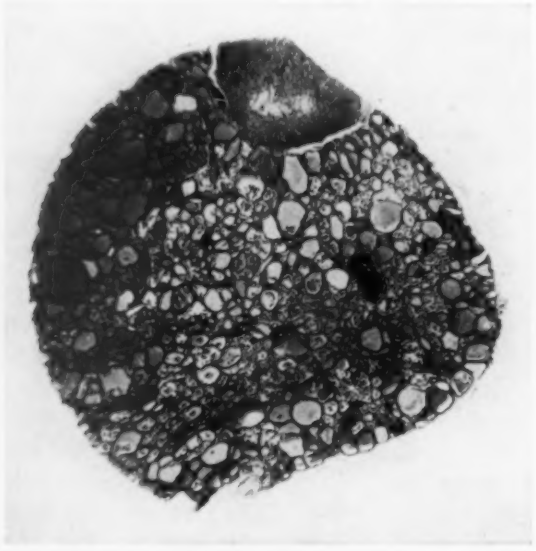

FIG. 6. Dog 2A. Hyperplasia of the thyroid.

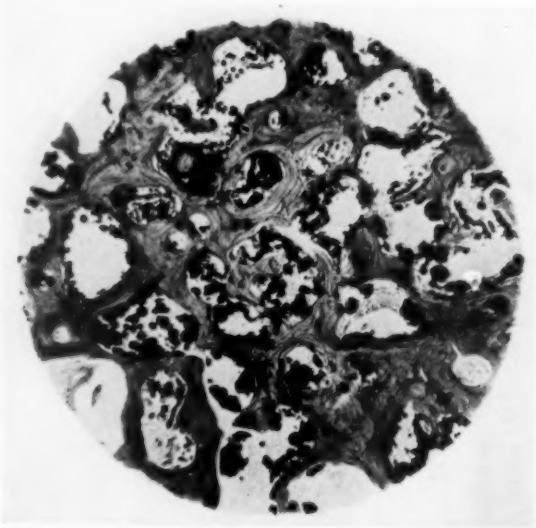

FIG. 7. Dog 3. Replacement of bone marrow by calcium.

The roentgen studies of the bones revealed no significant changes (Figs. 12 and 13).

Two of the dogs receiving the growth hormone and parathyroid extract showed hyperplasia of the thyroid and a third showed changes of a colloid nature. These changes in the thyroid gland are probably attributable to the growth hormone of the pituitary. That such changes in the thyroid are sometimes met under normal conditions is true, but the fact that the fourth dog not receiving growth hormone did not show any thyroid change suggests that the thyrotropic hormone in the extract was responsible.

The follicular changes in the ovaries were no doubt due to the gonadotropic influence of the pituitary extract.

BLOOD CHEMISTRY STUDIES (CHART 1)

In Chart 1 is given a curve of the blood analyses of Dog 1A during the period of the experiment. The other curves showed but little deviation from this one.

The blood calcium did not show any great variation despite daily injections of sufficient quantity to raise the blood calcium normally. Of interest, however, is the behavior of the blood calcium when sugar (glucose) was added to the diet. All animals showed a significant increase in blood calcium. Below are the tables showing the changes when glucose was added to the diet.

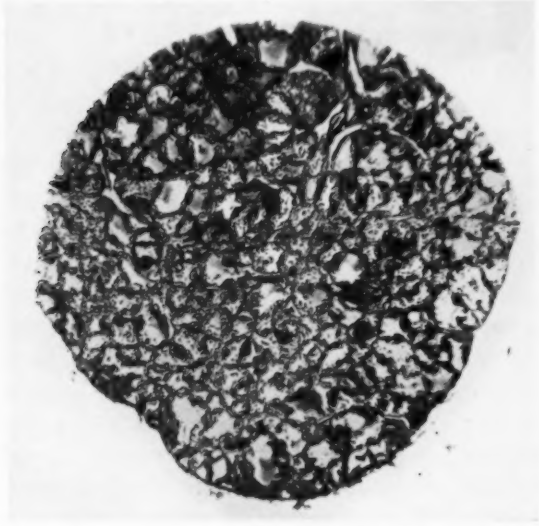

FIG. 8. Dog 3. Hyperplasia of the thyroid.

FIG. 9. Dog 3. Acute passive congestion of the liver.

TABLE I

BLOOD CALCIUM

Dog 1 A.	10.18 to 14 mg. = 3.82 mg.
Dog 2 A.	10.40 to 14.28 mg. = 3.88 mg.
	Average increase, 3.15 mg.
Dog 3.	10.84 to 12.98 mg. = 2.14 mg.
Dog 4.	11.04 to 13.8 mg. = 2.76 mg.

Dog 3, which developed exophthalmic goiter, showed the least change.

FIG. 10. Dog 3. Calcium deposits in the follicles of the ovary.

TABLE II

BLOOD PHOSPHORUS

Dog 1 A. 2.8 to 2.2 mg. = −0.6 mg.
Dog 2 A. 3.05 to 2.83 mg. = −0.22 mg.
Average decrease, 0.23 mg.
Dog 3. 3.8 to 4.2 mg. = +0.4 mg.
Dog 4. 2.65 to 2.16 mg. = −0.49 mg.

Again Dog 3, with exophthalmic goiter, showed a reversal of the trend in other dogs.

TABLE III

BLOOD PHOSPHATASE (BODANSKY UNITS)

Dog 1 A. 2.88 mg. to too low to be read.
Dog 2 A. 2.01 to 2.83 mg. = +0.82 mg.
Dog 3. 2.18 to 1.08 mg. = −1.10 mg.
Dog 4. 1.84 mg. to too low to be read.

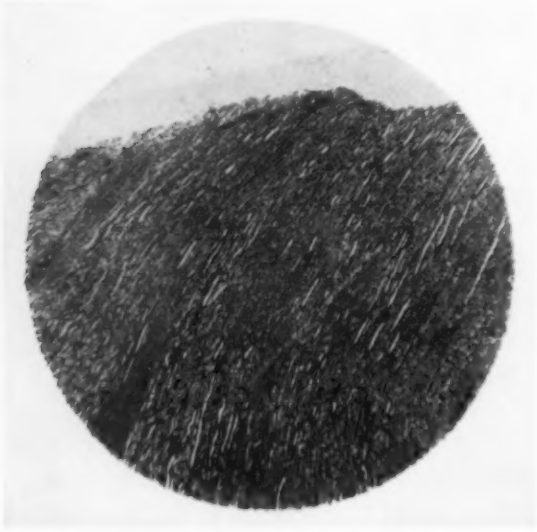

FIG. 11. Dog 4. Calcium deposits in kidney.

When the calcium was highest, the phosphatase reached its lowest level. This effect was only a transitory one as shown by the curve.

The influence of alimentary glycemia on phosphatase is of interest. Bodansky[1] found a marked increase in phosphatase when a high carbohydrate diet was given, our findings being the exact opposite. The discrepancy will be explained later.

TABLE IV

BLOOD SUGAR

Dog 1 A. 0.089 mg. at beginning; 0.087 mg. at point of high calcium level.
Dog 2 A. 0.080 mg. at beginning; 0.066 mg. at point of high calcium level.
Dog 3. 0.097 mg. at beginning; 0.069 mg. at point of high calcium level.
Dog 4. 0.097 mg. at beginning; 0.76 mg. at point of high calcium level.

It is seen, therefore, that instead of the sugar rising on the high carbohydrate diet it was depressed. What then can be the explanation of these various changes, high calcium, low phosphorus, low sugar, low phosphatase readings?

We can, first of all, exclude the anterior pituitary extract's (diabetogenic hormone) influence on the blood sugar, since the same findings were present in the dog that did not receive this extract. In view of Bodansky's work,[1] in which he showed elevation of the sugar and phosphatase, we are forced to the conclusion that the behavior of the blood sugar and phosphatase was due to the parathyroid extract. Johnson's work[3a] also proved this to be true. Ferrannini[4] found that in normal subjects parathyroid extract lowers the glycemic rate during fasting and increases carbohydrate tolerance. The action of the parathyroid extract on the glycemic curve, when compared with that of epinephrine, is almost like that of insulin. In diabetes the parathyroid extract lowers the glycemic curve and the glycosuria on fasting. He says there is no doubt about the insulin-like action of parathyroid extract in normal subjects and in diabetic patients.

Johnson[3a] administered calcium gluconate alone and in combination with parathyroid extract to six dogs under ether anesthesia and the blood sugar changes were noted. Following the administration of calcium gluconate and calcium gluconate in combination with parathyroid extract the portal vein blood sugar fell rapidly and continuously during the period of the experiment. The lowest levels were reached under the influence of the combined action of calcium gluconate and parathyroid extract (both given intravenously). In the control animals the portal blood sugar showed a consistent rise, as might be expected under the influence of ether anesthesia. From these experiments he con-

cluded that the fall of blood sugar is due to impaired absorption of glucose from the gastrointestinal tract. He pointed out in this paper that the extent of the fall was in relationship to the original level of the blood sugar—the higher the original level, the greater the extent of the fall. He further pointed out that the fall in blood sugar paralleled the rise of blood calcium and that there was a rather definite inverse relationship.

Fig. 12. Roentgen study of bones of Dog 4 at the beginning of the experiment, May 5, 1934.

Fig. 13. Roentgen study of same bones (Dog 4) at conclusion of experiment, January 10, 1935.

We learned that an immunity, as measured by the blood calcium, to large doses of parathyroid extract was soon established. This is also true of clinical cases of chronic tetany, where large doses become necessary to produce improvement. What the actual mechanism is was not learned from the necropsies. Whether this is a confirmation of Collip's antihormone hypothesis[5] is open to question.

Jaffe, Bodansky and Blair[6] produced bone lesions similar to osteitis fibrosa cystica by injecting parathyroid extract into dogs and guinea pigs. They concluded from their work that the lesions produced were similar to those of human osteitis fibrosa cystica due to parathyroid tumors. Johnson,[3b] using rats and puppies, was able to produce osteitis fibrosa osteoplastica (von Recklinghausen) by repeated injections of parathyroid extract.

Outstanding in the blood studies was the behavior of the blood sugar, calcium, phosphorus and phosphatase when glucose was added to the water. The rise in blood calcium, the lowering of the blood sugar, phosphorus and phosphatase seems to us of some importance. We reasoned that if the phosphatase could be so strikingly lowered in this way such a reaction would be of benefit to persons suffering from Paget's disease. It is, of course, well known that phosphorus compounds take part in the storage or utilization of carbohydrates and that they are necessary for the deposition of bone.

From our clinical studies[7] on a small series of patients suffering with Paget's disease, we found that they gave, in 40 per

cent of cases, a familial diabetic history and that they themselves (10 cases examined) had glucose tolerance curves suggesting a diabetic tendency with low tolerance. What appears to be striking support of our clinical work in this regard are the laboratory studies of Schelling[8] in which he showed that depancreatized dogs showed a

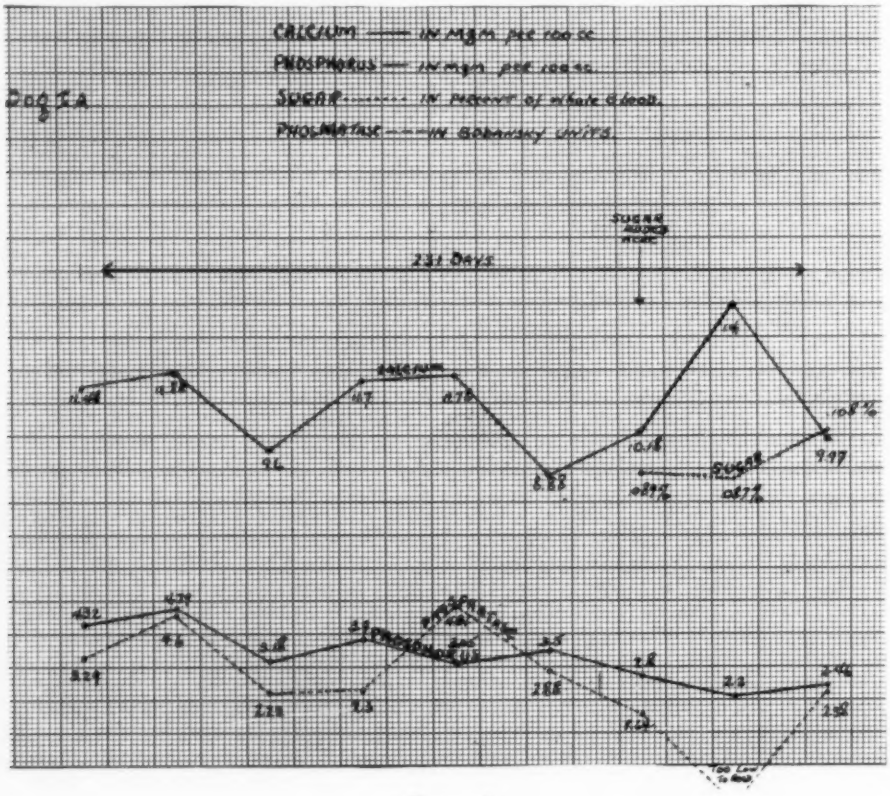
CALCIUM —— IN MGM. PER 100 CC.
PHOSPHORUS —— IN MGM. PER 100 CC.
SUGAR ------ IN PERCENT OF WHOLE BLOOD.
PHOSPHATASE - - - IN BODANSKY UNITS.
Dog K.A.
231 Days
SUGAR ADDED TO DIET

Chart I

very high blood phosphatase. The height of the blood phosphatase reached the levels seen in Paget's disease (40 units). He was unable to lower the phosphatase to any great extent with insulin.

We placed the patients with Paget's disease on a measured diet plus insulin.* Instead of using parathyroid extract, whose effect was not of long duration as shown by the experimental work, we used, as stated above, insulin.

Whether the effects of the measured diet and insulin will stop the progress of Paget's disease, whether it will produce regression of the disease, how long it must be continued, what blood sugar level must be maintained, and whether the effect is also but temporary are questions that further study will answer. It would seem that these patients, who apparently have a low tolerance for sugar, would be benefited by the measured carbohydrate diet and insulin, for we reason that pathologic bone changes may be the result of improper carbohydrate and phosphorus metabolism. At any rate, as we have reported elsewhere,[7] the clinical improvement is very striking. The patients become free of so-called "bone pains" in the head, arms, pelvis, legs and spine, they feel stronger and are much brighter. This is paralleled by a drop in blood phosphatase and is accomplished within a week. These patients are ambulatory and so bed rest is not a factor.

* Carbohydrate 175–200 gm.; protein 70 gm.; fat 50 gm. Insulin 10–15 units three times per day.

In the clinical studies on Paget's disease we suggested that the disease process might be due to a pituitary disturbance which would account for the findings in our series of familial diabetes, familial tallness and familial obesity. It would seem that studies of bone diseases should take into account the function of the pituitary gland in its relation to carbohydrate and phosphorus metabolism and to bone development and function. Recently Funsten[9] has reported disturbances of carbohydrate metabolism in fractures.

SUMMARY

An attempt was made to produce bone lesions (Paget's disease) in adult dogs by the use of anterior pituitary growth hormone and parathyroid extract. Four dogs were observed over an average period of two hundred thirty-one days, divided arbitrarily into three periods, viz., of one hundred, fifty-five, and seventy-six days respectively. Three dogs received combined injections of growth hormone and parathyroid extract daily, and the fourth dog received only parathyroid extract daily. The average amount of growth hormone given was 358 c.c., the average amount of parathyroid extract given was 13,008 units.

The outstanding findings in the three dogs receiving pituitary growth hormone and parathyroid extract were the massive replacement of bone marrow by metastatic calcium. That the growth hormone played a rôle in this replacement by calcium is indicated by the fact that the fourth dog receiving parathyroid extract alone did not show these changes.

Three of the dogs showed calcium deposits in the kidney, the greatest changes of this nature being in the dogs receiving growth hormone and parathyroid extract. Attention is called to the clinical condition of hyperparathyroidism with nephrolithiasis.

Two of the three dogs receiving growth hormone plus parathyroid extract showed thyroid changes such as seen in exophthalmic goiter, the third dog of this group showed changes of a colloid nature in the thyroid gland. This was thought to be due to the thyrotropic hormone of the pituitary extract.

Excessive ovulation was shown to be present in these three dogs, which was also attributed to the gonatropic hormone of the pituitary extract.

During the course of the experiments, for a period of forty days, a high carbohydrate diet plus parathyroid extract raised the blood calcium, lowered the blood sugar, blood phosphorus, and blood phosphatase. This was but a transitory effect.

Our clinical studies, as shown elsewhere, would indicate that a constitutional background is necessary for the production of Paget's disease. We found that a high percentage of patients suffering from Paget's disease have a constitutional background of familial diabetes, familial obesity, and familial tallness.

We have placed these patients on a measured carbohydrate diet (175–200 gm. of carbohydrate) and insulin (10–15 units three times per day). The results observed over a short period of time with this regimen have been striking. The patients lose their so-called bone pains within a few days and this is accompanied by a drop in the blood phosphatase. It is of course too early to say how long these benefits will endure. Likewise continued observations by clinical, roentgenological, and laboratory studies are necessary to see what influence, if any, this regimen will have.

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INTERLOBAR PLEURAL EFFUSIONS*

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IT has long been known that exudates may occur in recesses of the pleural cavity where their detection on physical and the usual roentgenographic examination is extremely difficult. Among these are exudates in the costophrenic angles, the anterior and posterior mediastinal aspects of the pleurae, the retrocardiac area, and particularly the interlobar fissures. However, in this presentation, consideration will be given only to the salient diagnostic features of interlobar exudates.

Exudates in the interlobar fissures are not of mere academic importance, and they are by no means as infrequent as the paucity of reports in the literature would indicate. They may occur in any of the fissures, and, in one instance, an exudate was found in the azygos fissure on the right side. They cast roentgen shadows which are misinterpreted with unbelievable frequency. They account for many of the so-called mild and atypical pneumonic processes, and, on occasion, they are confounded with intrathoracic neoplasms which disappear miraculously with and without therapy. Moreover, a great many cases of unresolved pneumonias if not found to be due to tuberculous processes are, in reality, either primary interlobar exudates or exudates complicating recently resolved pneumonic infections.

Experience has also shown that transudates secondary to circulatory failure may accumulate in interlobar fissures and thus closely simulate pulmonary consolidation or intrathoracic neoplasms.

SYMPTOMATOLOGY

Interlobar pleurisy, as a rule, makes its appearance in much less stormy fashion than lobar pneumonia, with which it is often confused. There may be some chills and a moderate amount of fever, and while the cough may be quite distressing, there is no bloody sputum. There may be dull pain in the chest, particularly near the site of the pathological process, but it is constant and not particularly aggravated by the respiratory effort. In such cases, a diagnosis of lobar pneumonia is usually made.

On the other hand, an interlobar exudate may develop with so few constitutional disturbances and only moderate pain and cough, that its accidental discovery on the chest film may be most disconcerting. It is in cases of this type, particularly if the patient is past middle age, that an intrathoracic neoplasm is not only feared, but often diagnosed.

PHYSICAL FINDINGS

The meagerness of physical findings in interlobar pleurisy is, in itself, of the greatest diagnostic importance, so that, in a given case, with roentgenologic evidence of apparent pulmonary consolidation but without the usual frank physical findings of consolidation, the possibility of the existence of an interlobar exudate is to be seriously considered. While it is true that occasional harsh breathing and rarely small moist râles may be heard in the proximity of the interlobar area when an appreciable interlobar effusion has developed, the usual dullness on percussion, bronchial breathing, bronchophony, moist râles, and increased tactile fremitus elicited in pneumonia are not observed in interlobar pleurisy.

COURSE OF THE DISEASE

Valuable data in the differential diagnosis can be gleaned from the course of the disease in each instance. Regardless of the height which the temperature reaches in interlobar exudates, a critical drop is rarely

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observed as in the majority of cases of lobar pneumonia; nor does the blood count show as high a leukocytic response and preponderance of neutrophiles in interlobar effusions, as compared with lobar pneumonia. Moreover the disappearance of the lesion in interlobar pleurisy is much slower than in uncomplicated pneumonic processes.

ROENTGEN DIAGNOSIS

While the existence of interlobar exudates may be suspected from the meagerness of physical findings in the chest, and suggestive roentgenographic shadows, a definite diagnosis can be safely made only with the aid of chest films taken in positions which bring the fissure under suspicion at right angles to the film. It is only in this fashion that interlobar exudates will cast their maximum diagnostic shadow on the plate. Exudates in the main interlobar fissure, either on the right or left side, can best be detected on films taken in true lateral position with the side involved next to the film.

The right upper interlobar septum is so often visualized in the usual posteroanterior chest film because in this position the anterior aspect of the fissure is at right angles to the plate. Whether or not the thickening observed in this area in normal chests is due to a previous localized inflammatory process is not within the scope of this discussion. But experience has shown that even in this fissure, exudates are best demonstrated in true right lateral position which brings the lateral aspect of the fissure at right angles to the film.

INTERLOBAR EXUDATES SIMULATING PULMONARY NEOPLASMS

Interlobar exudates will rarely simulate endobronchial neoplasms, which, by plugging of the affected bronchi, cause an extensive atelectasis of the tributary lung area. In such cases, the displacement of the trachea and mediastinal contents toward the involved side, the narrowing of the interspaces and retraction of the diaphragm on the side of the lesion, in addition to the dense unilateral lung shadow, are quite characteristic.

It is different in the case of the rare alveolar type of tumor, which usually arises in the parenchyma of the lung, and, for a time, grows in globular fashion near the center of the lobe, or the hilar type of tumors, which originate in the hilar structures, and grow outward toward the periphery. These may easily be confused with an interlobar collection of fluid. If lateral films show these supposed tumor shadows to be intimately connected with an interlobar fissure, time and patience may prove them to be due to interlobar exudates which slowly but surely disappear.

REPORT OF CASES

The following cases have been chosen to illustrate the clinical and roentgenologic features of interlobar exudates.

Case 1. R. K., a white girl, aged eighteen, who had a tuberculous mastoid at four years of age, and since, a pronounced lupus vulgaris, was taken ill with chills, fever, and pain in the left chest on November 9, 1931. A diagnosis of lobar pneumonia on the left side was made, but in spite of the usual therapy, the fever continued and rose to 104–106° F. every afternoon for forty-seven consecutive days. When she came under my care on the twenty-seventh day of her illness, physical examination disclosed a questionable slight dull percussion note in the lower axilla on the left side. The breath sounds were harsh, but not bronchial. There were no râles. At this time an anteroposterior bed-side film showed a dense shadow occupying the lower outer three-fourths of the left chest, which was interpreted as a pneumonic process (Fig. 1*a*).

However, because of the meager signs and protracted course, the existence of an interlobar effusion was suggested, and the patient was removed to the Harlem Hospital for further study on December 16, 1931. Her blood Kahn reaction was negative. The white blood count was 13,700 with 78 per cent polymorphonuclear leukocytes. The urine was negative. A diagnostic tap was done at the fourth space in the anterior axillary line. When it was felt that the needle had passed the pleura, no fluid

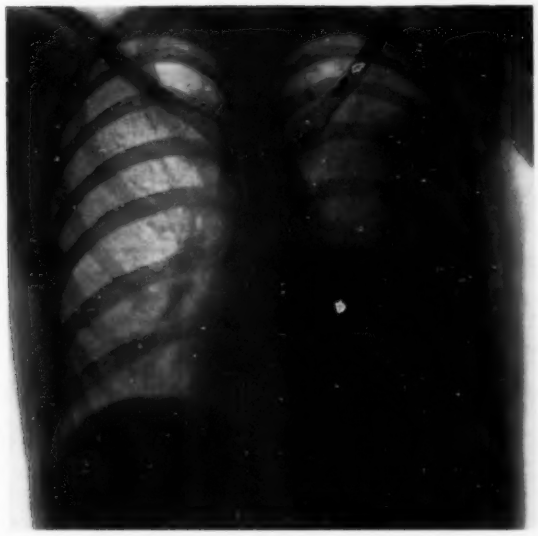

Fig. 1*a*. Case I. Anteroposterior view, showing dense shadow occupying lower two-thirds of left chest.

Fig. 1*b*. Case I. Left lateral view showing accumulation of fluid in interlobar fissure.

could be aspirated. Going a little deeper, the lung tissue was punctured and air aspirated. On advancing the needle further, clear fluid was aspirated. Figure 1*b*, taken in the left lateral position, shows the interlobar exudate. Patient was discharged in good condition on January 12, 1932.

Case II. R. B., a colored man, aged forty-eight, was admitted to the Harlem Hospital on January 22, 1932, stating that he had not been well for about a month. He was suffering from headache, weakness, slight cough, and discomfort across the shoulders. He thought he had lost weight, but had no dyspnea, hemoptysis or night sweats. Physical examination disclosed a questionable dull percussion note below the right scapula, with slightly diminished breath sounds, but neither egophony nor bronchophony could be elicited. The total white count was 22,600 with 87 per cent polymorphonuclear leukocytes, and 13 per cent lymphocytes. On one occasion there was an eosinophilia of 6 per cent. The temperature ranged between 98–101° F. Kahn reaction of the blood was negative, as were the urine and numerous sputum examinations for acid-fast bacilli.

Roentgenogram of the chest on admission (Fig. 2*a*) disclosed a large shadow about 4 inches in diameter in the upper third of the right lung, and one about 5 inches in diameter at the right base. The outlines were sharply defined. At the lower aspect of the upper shadow there was a small round extension. These shadows were thought to be due to echinococcus cyst formation.

Fig. 2*a*. Case II. Posteroanterior view, showing dense homogeneous shadow about 4 inches in diameter in the upper half of the right chest, and a similar shadow in the right lower, inner portion.

Fig. 2*b*. Case II. Right lateral view, showing thickened right interlobar septum with effusion in its upper aspect; also an encapsulated effusion at the right base posterior.

Roentgenogram of the chest, taken on February 2, suggested the existence of a neoplasm. However, because of the practically negative physical findings, and the contrasting extensive roentgenographic shadows, a diagnosis of interlobar exudates was made. Figure 2*b*, taken in the right lateral position, confirmed the diagnosis.

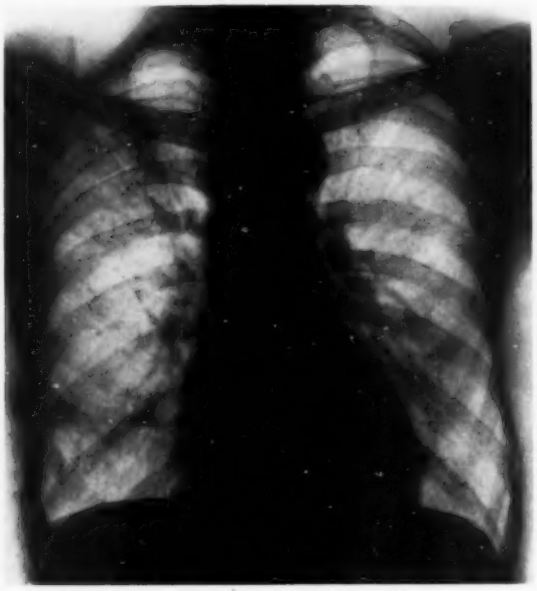

Fig. 3. Case II. Roentgenogram taken four months later, showing complete disappearance of effusions.

The patient continued to improve, and was discharged in good condition on February 17, 1932. The most recent film (Fig. 3) taken four months later, shows complete clearing of the exudates.

Case III. A. W., an electrical engineer, aged thirty-six, stated that five years prior to his

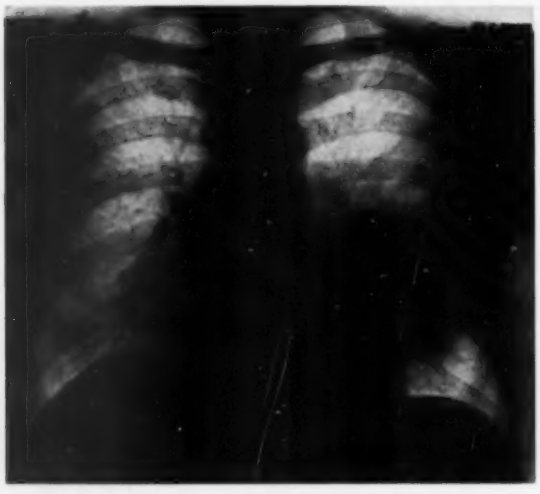

Fig. 4*a*. Case III. Showing dense shadow in the lower inner half of the left chest, intimately connected with that of the heart.

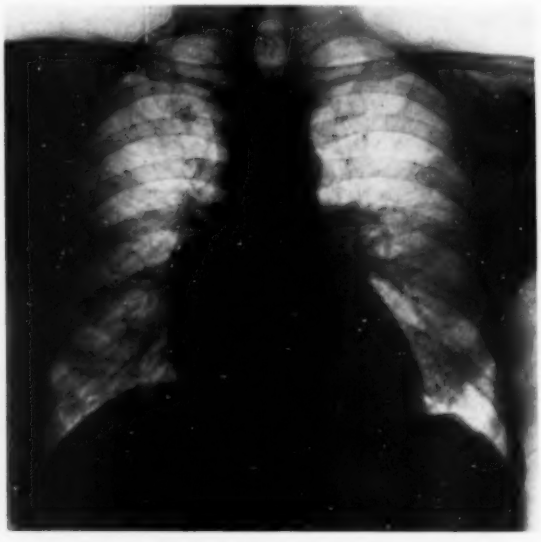

Fig. 4*b*. Case III. Showing complete disappearance of the shadow three weeks later; note prominent heart.

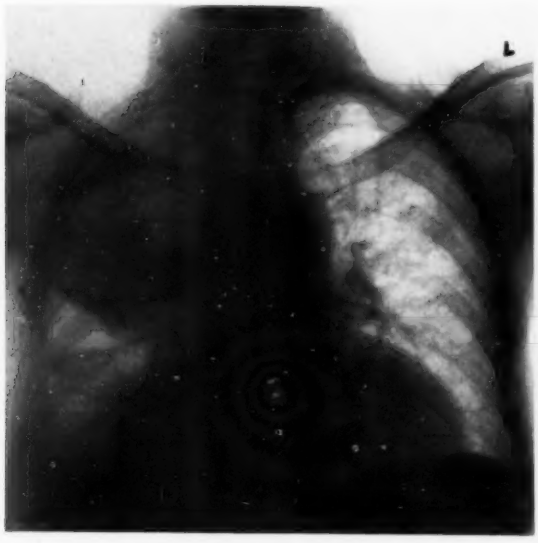

Fig. 5*a*. Showing marked transudate in right upper, and right costophrenic sinus.

Fig. 5*b*. Right lateral view, showing interlobar transudate between right middle and lower lobes; fluid level above due to injection of air.

present illness, he had fractured two ribs on the left side when he stopped his car suddenly, and fell against the steering wheel. Recovery promptly followed. Three months later, he had pain in the left chest, and dyspnea after cranking his car, but recovered rapidly, and was well until August, 1933. At this time he developed a cough, his expectoration was often blood-tinged, and he had marked dyspnea on slight exertion. No fever or sweats were noted.

Physical examination disclosed a few indefi-

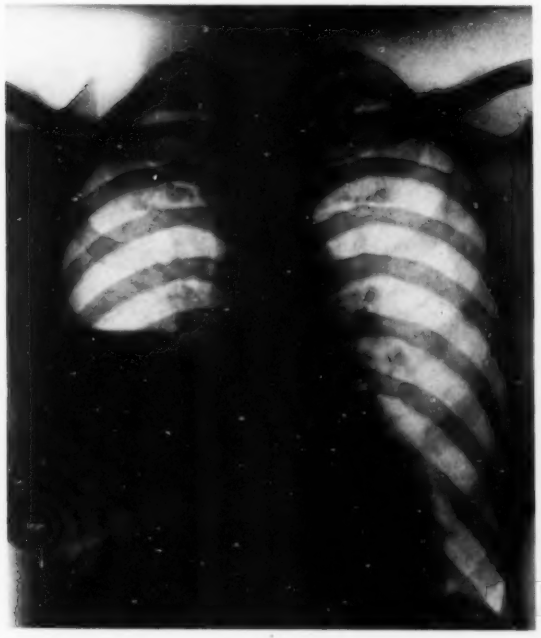

Fig. 6*a*. Showing dense shadow in region of right middle lobe.

Fig. 6*b*. Right lateral view, showing collection of fluid in this area.

Fig. 7*a*. Posteroanterior view, showing transudate in region of right middle lobe.

Fig. 7*b*. Right lateral view, showing interlobar effusion between right middle and lower lobe.

nite râles at the left hilus. Chest film (Fig. 4*a*) showed what appeared to be a neoplasm in the left hilar region. Bronchoscopy was advised by his physician, but the patient insisted on further consultation. When first seen on August 25, 1933, the physical findings were unchanged. The heart was moderately enlarged and roentgenoscopy in the left lateral position suggested an interlobar collection of fluid. There was a definite lack of cardiac reserve and exercise tolerance was limited; the blood pressure was 120/80.

Fig. 8. Showing exudate in the azygos fissure, also moderate effusion right base.

An electrocardiographic tracing disclosed an inverted T in lead 1, marked splintering of the RS complex in leads 2 and 3—definite evidence of myocardial damage.

On rest in bed there was marked improvement in the cardiac condition and the shadow in the left hilar region disappeared completely (Fig. 4*b*).

SUMMARY

1. Interlobar pleural exudates occur with greater frequency than the reports in the literature on the subject would indicate.

2. These exudates are usually mistaken for mild or atypical pneumonic processes with delayed resolution. Less often they are confounded with intrathoracic neoplasms which disappear miraculously with and without therapy.

3. In contradistinction to pulmonary consolidation, where dullness, moist râles,

and bronchial breathing are most often elicited, in addition to the dense shadow on the chest film, there are practically no abnormal physical findings in spite of the roentgen densities in the case of interlobar exudates. It is this persistent lack of abnormal physical signs in cases showing roentgenographic evidence of pulmonary consolidation that suggests the existence of interlobar exudates.

4. Exudates and transudates may occur in any of the interlobar fissures. The most common and most easily discovered are those between the right upper and middle lobes, but they may be seen even in the azygos fissure on the right side.

5. Because the anterior aspect of the horizontal fissure is at right angles to the anterior wall of the right hemithorax, exudates in this region are most easily seen in the usual chest film taken in the postero-anterior position. Exudates in the oblique fissure can best be elicited in true lateral positions, with the side involved next to the film, because these are the only positions that bring the fissures at right angles to the film. Films taken in the oblique or postero-anterior positions are of little value in such cases.

6. Shadows in chest films simulating neoplasms should be studied with the aid of roentgenograms taken in the true lateral positions. If found at the interlobar fissures, these abnormal densities should be interpreted with caution because, on occasion, they are due to harmless exudates or transudates which slowly but surely disappear.

NEOPLASMS OF THE ORAL AND UPPER RESPIRATORY TRACTS TREATED BY PROTRACTED ROENTGEN THERAPY*

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AT ITS annual meeting, three years ago, the American Roentgen Ray Society was addressed by Dr. Henri Coutard of Paris. His subject was "Roentgen Therapy of Epitheliomas of the Tonsillar Region, Hypopharynx and Larynx."[1] True to the tradition of a great scientist, he brought before you not only the benefits derived from the use of his principles in the treatment of upper respiratory malignancies, but he also stressed the complications and dangers that may occasionally accompany the treatment. However, he emphasized the precautions which might be taken to avoid or minimize these untoward sequelae. The comment upon the presentation was varied and many felt that it was too dangerous for use in spite of the fact that up to then no other method was available which gave consistent results in the treatment of these lethal malignancies of the upper respiratory passages. During the last few years many clinics, both here and abroad, have undertaken the treatment of these malignancies by external irradiation. In the main, they have followed Coutard's principle of daily protracted fractional doses of radiation, but they have deviated from the other basic principles which he believes should be followed to obtain the best results, especially in the more radioresistant tumors. Thus far no mention has been made of a Coutard method because many have questioned the fact that there is a Coutard method and it has been asserted that Coutard himself varies certain factors in many cases. This is undoubtedly true in some instances, but with all his variations certain basic principles, which have proved to his satisfaction to be sound, have always been used. As to his variation in technique, the answer is quite simple: first, certain factors are still uncertain and it is only by trial and study that the optimum conditions can be determined; second, there are variations in individual response which call for a change from any fixed plan; third, Coutard ends his most recent publication[2] with the following remarks: "There exists no fixed method of treatment but a simple clinical treatment for each individual patient and for the special type of tumor." No one can find fault with one who individualizes his treatment. Also, there can be no criticism of those who feel that they can obtain equally good results by modifying certain factors. However, it does seem unsound to make modifications only for the economy of time and expense unless comparable or better results are obtained. Unfortunately, it is only after a number of years that the results from the modification of any technique used in the treatment of malignant disease can be truly evaluated.

In general hospitals where the cancer material is small, modifications of technique may be dangerous. Most of us must be followers in the battle with cancer and we must accept what we feel is the best practice of the day and use that method which promises most to our patients. If we feel that our equipment is not adequate or that time is not available to give the patient the best chance for cure, we should not undertake this treatment.

The basis for the evolution of Coutard's principles in the radiation therapy of malignancies is a biophysical one. The concept of the importance of the conservation of the bed, or as Coutard calls it, the vasculo-connective tissue in which the

* From the Department of Radiotherapy, Mt. Sinai Hospital, New York City. Read at the Thirty-fifth Annual Meeting, American Roentgen Ray Society, Pittsburgh, Pa., Sept. 25–28, 1934.

malignancy grows, has been mentioned by Ewing and others. Coutard, however, has taken steps in planning the treatment for this conservation, whereas thegeneral trend is to saturate the tumor up to the point of skin toleration and to depend upon the direct carcinolytic action of the radiation.

This direct action upon the tumor may be the *modus operandi* in lymphosarcomas and in the undifferentiated epitheliomas where "the tumor cells usually die within fourteen days, more rarely within twenty-five days," but Coutard says that "in a highly differentiated tumor, either an epidermoid epithelioma with prickle cells predominating which is infiltrating muscle, or a tubular adenocarcinoma, the radiomodifications of the vasculo-connective tissue are of the utmost importance because the radiosensitivity of these tumors is slight."[2] Because of this lack of radiosensitivity in the highly differentiated tumors, it is felt by Coutard that cure is effected by evolution (i.e., by a slow saturation effect of these cells by radiation thus hastening their maturation and death). It is therefore understandable why every effort must be made to preserve the integrity of the vasculo-connective tissue for the maintenance of its nutrition during the evolution of the neoplasm and until it is eradicated. Furthermore, Coutard says that the vasculo-connective tissue is extremely labile and that there may be individual variations in its irritability. Because of this, close study must be made of each patient during treatment and undue changes such as edema early in the treatment, marked congestion of the mucous membranes, or early appearance of radioepithelitis are indications of injury to the vasculo-connective tissue and that the treatment is being given too rapidly. Again, extreme modifications of the vasculo-connective tissue have a tendency to cause marked skin changes with late radionecroses.

In order to minimize this undue trauma to the vasculo-connective tissue Coutard[2] uses the following factors:

Table I

1. Voltage 190–200 kv.
2. A filter of 2 mm. zinc plus 3 mm. aluminum, covered by 3 cm. of wood.
3. Focal skin distance of 50–60 cm. for the head and neck. For deep-seated lesions, such as the uterus, 80–100 cm.
4. Rate of flux 3–5 r per minute measured with back-scattering.
5. Number and size of portals vary with site and size of the lesion and the extent of glandular spread.
6. Time of irradiation for
   (a) Small embryonal tumors—20 days plus
   (b) Large tumors or differentiated tumors—40 days plus up to 90 days.
7. Depth dose in cured cases
   (a) Radiosensitive noninfiltrating—3000–4000 r (with back-scattering)
   (b) Radioresistant—4000 r plus

The principle of daily protraction of fractional doses of radiation, as advanced by Coutard, has been generally accepted. The main deviations from Coutard's factors are:

1. The use of high milliamperage technique 8–30 ma.
2. The use of a thinner filter (0.5 mm. Cu).
3. The increase in both daily and total dosage by about 33 per cent in some cases.
4. The useof uniform techniques for all clinical and pathological varieties of cancer.

It is Coutard's belief that the use of the above mentioned factors which give a high rate of r flux per minute are responsible for modifications of the vasculo-connective tissue and also that they may be the cause either of failure to cure, early metastases or the appearance of late radionecrosis. If this theory regarding the importance of the vasculo-connective tissue in the radiation therapy of cancer is correct, it seems logical to accept Coutard's ideas as to the importance of the time factor and possibly the change in quality, though small, that one obtains in using 2 mm. Cu rather than 0.5 mm. Cu.

As regards damage to normal tissue, an analogy may be made with the practice of giving intravenous injections of toxic medications slowly. In fact, the more recent practice of giving certain substances by the

continuous drip increases the tolerance of the organism to larger doses than could be safely given by the rapid injection method. This is undoubtedly the basis for the principle of protracted radiation therapy. It would therefore seem that a slow rate of r flux per minute would increase both healthy tissue and vasculo-connective tissue tolerance.

The following table illustrates the marked variations that exist where high milliamperage technique or a thin filter or where both are used.

Table II

PHYSICAL FACTORS FOR 300 r
MEASURED IN AIR—180–200 KV.

	Distance 50 cm.				
	Size Field	ma.	Filter	Time	r per min.
Memorial Hospital	9 cm. diam.	30	0.5 mm. Cu	7 min.	28
Presbyterian Hospital	10×10 cm.	8	2.0 mm. Cu	20 min.	15
Montefiore Hospital	10×10 cm.	25	0.5 mm. Ag	13 min.	21
Mt. Sinai Hospital	10×10 cm.	4	2.0 mm. Cu	60 min.	5

	Half-value layer
Effective wave length—0.5 mm. Cu–0.16Å	0.9
2.0 mm. Cu–0.12Å	1.8

		ma.	Filter	Time
Mt. Sinai	60 cm. distance	4	2.0 Cu	75 min.
Hospital	60 cm. distance	3	2.0 Cu	90 min.

The prolongation of the time is quite evident from the above table where through the use of low milliamperage and heavy filter, the exposure time is increased eight to thirteen times. In many instances we have prolonged the time to 120 minutes for an equal amount of radiation by increasing the distance and lowering the milliamperage, thus making a difference of 1,700 per cent.

Again there is a difference in the effective wave length and in the half-value layer in copper through the use of a filter of 2 mm. Cu. Although this difference is small, it is theoretically conceivable that it may result in a different cytological response.

The above points are brought out for a clarification of the situation as it exists today rather than as a criticism of any particular technique. Cancer is still a most difficult disease to cure by any method of treatment. It may be possible that time will teach us that there is no advantage in using a heavier filter with voltages up to 200 kv. In fact, many physicists are quite certain of this. Experience may teach us that a slow rate of r flux (3–5 r per minute) is also unnecessary. These facts can be proved only by time and by a careful study of our material. The universal goal is the cure of cancer. This should be done without permanent damage to the healthy tissues if possible. No damage, however, should be countenanced, if the cancer is beyond control, and if in our attempt we may make the patient more miserable than he would have been without treatment. A patient who dies of radionecrosis is no better off than one who succumbs to cancer. The limits of tolerance of healthy tissues should be known. Lack of experience with this form of therapy may tend toward undertreatment which is also dangerous for it may result in failure to cure.

During the last three and a half years, we have followed the principles of Coutard in the treatment of certain extensive oral malignancies which were not suitable for local radium therapy, and in the treatment of intrinsic and extrinsic laryngeal carcinoma. Although the material is numerically small and although the time since onset of treatment is relatively short, it is felt that this presentation may be of interest to those who have not used protracted roentgen therapy and that it may

be of some help to those who have just begun its use.

GENERAL CARE OF THE PATIENT

Before treating any patient, a complete physical examination is made which includes blood studies and such roentgen examinations as may be indicated. A biopsy is taken in all cases. The patient is seen by a dentist and the teeth are cleaned. All decayed teeth and any teeth that may be doubtful are extracted. This is done in all cases whether the lesion is in the oral or pharyngeal cavity. We feel that good oral hygiene, besides its importance in aiding the eradication of an oral malignancy, prevents both local injuries and respiratory complications.

Immediate steps are taken for the maintenance of the patient's nutrition. The caloric needs are supplied by high caloric fluids when deglutition is painful. In some cases nasal feeding by the Levin tube is used. We advise a high fluid intake in all cases. Continuous intravenous drip of glucose was used in one case where the nasal tube could not be passed; in another case, gastrostomy was necessary. These measures should not be delayed too long. The patient should be weighed daily and an estimate should be made of his caloric intake. Diabetes, if present, should be under control before therapy is begun. Lues if not active is not treated. If a great deal of blood has been lost or if the nutrition is extremely bad, preliminary blood transfusion is of great help. In fact, it may be wiser, in some cases, to improve the general condition of the patient before beginning radiation therapy. Complications will be fewer and the result will be better by delaying the treatment for a week or two if necessary. It is my belief that therapy is more effective when this plan is followed.

Preliminary tracheotomy is done only when there is immediate danger of complete obstruction. The patients are examined daily to determine the question of obstruction in the pharynx or larynx and to observe the local reaction. Smoking and the drinking of hard liquor are contraindicated in intrinsic and extrinsic neoplasms of the larynx during the treatment and the reaction stages. Cocaine and nupercaine in sprays and local applications, and anesthesine tablets are prescribed for local pain and dysphagia. Coal tar products and codeine either by mouth or by rectal suppositories are used freely for the alleviation of pain. Barbitols are used for insomnia. For oral cases, we advise numerous and copious irrigations with normal saline and mouth washes after eating.

PLAN OF ROENTGEN THERAPY

When the diagnosis is definitely established, a tentative plan of treatment is outlined. The exact extent of the lesion is determined and portals to cover the primary lesion and the draining lymphatic areas are mapped out. Portals larger than 150 sq. cm. are avoided if heavy protracted irradiation is to be given. If the disease is widespread, as, for instance, in a nasopharyngeal neoplasm with cervical nodes extending to the clavicles, four fields would be employed of 80–150 sq. cm. each rather than two larger fields. This is done to minimize the damage to the normal tissues and to increase the local tissue tolerance dose. For small lesions such as occur in the larynx, two fields extending from the mandible to the clavicles are used for the first third of the treatment. The fields are made smaller as the treatment continues so that the last third of the treatment is given through a portal 80–100 sq. cm. By using a larger portal there is a smaller chance of error if the patient moves. This often happens when each treatment lasts forty to sixty minutes. Furthermore, there is an increase in the depth dose by the use of a larger field.

Meticulous care is taken in the installation of each treatment. This is done by a physician specially trained in radiotherapy and by one who has examined the patient and who knows the exact area to be irradiated. The use of compression cones makes possible more accurate installations.

The circular portals described by Martin[3] of Memorial Hospital should be of value in the small lesions of the head and neck. They make possible greater precision in the installation and may have an advantage over square portals on physical grounds. Too much emphasis cannot be placed on the importance of the installation for each treatment by a trained physician. This work should not be delegated to a technician or to a person just beginning his training in radiotherapy. I have seen several failures that were due to technical errors.

Our treatments are given twice a day, morning and afternoon, and alternate fields are used. Our factors are 180 kv. constant potential or 200 kv. pulsating, 3–4 ma. with a filter of 2 mm. Cu plus 2 mm. Al; focal skin distance 50–60 cm. Our aim is to deliver to 3–5 r a minute. During the first three or four days small treatments (75–100 r) are given to avoid a severe reaction that may result from the lighting up of a latent infection and also to avoid what may be called acute sensitization of the neoplasm to the radiation. If there is no undue reaction after three or four days, 200 r, measured with back-scattering, is given to each of two fields daily except Sundays, until the total desired dosage is given.

Our total dosage was smaller during the first year of our work than it is at present. During this earlier period we rarely exceeded 3,000 r (measured with back-scattering) per field. During the last eighteen months we have increased our dosage to 3,600–4,200 r per field, 10×10 cm., if it is given in thirty or more days. It is not always possible to give these amounts in the occasional patient who has a very severe reaction. The mere presence of a mucositis or dermatitis per se should not interfere with the carrying out of a prescribed plan of treatment if the patient's general condition does not contraindicate it. The use of anterior and posterior portals in laryngeal cases has been abandoned during the last year. In the advanced intraoral lesions with massive unilateral cervical nodes, two portals for cross-firing on the side of the glands and one from the opposite side are still used.

In thirteen to twenty days, varying with the patient and the site treated, the radioepithelitis or mucositis appears. This lasts ten to fourteen days. At this time, the nutrition of the patient must be carefully watched and those measures used which were previously described to aid deglutition and to minimize pain. The radiodermititis, or skin reaction, usually closely follows the waning radioepithelitis or mucositis. Vaseline or boric acid ointment is used routinely for the skin; occasionally, nupercaine may be added if the burning sensation is too severe. The skin reaction, like the mucositis, heals in about two weeks if the daily and total doses have not been too large. If the treatment is greatly protracted forty to ninety days, the radioepithelitis and the radiodermititis should be very mild, according to Coutard.[2] The details of the skin and mucous membrane reactions and the modes of healing have been previously described by Coutard and will be omitted from this presentation.

Group I: Intraoral epitheliomas. Our first group consists of 12 cases of extensive intraoral adult type of squamous epitheliomas, all of which had enlarged cervical nodes. The disease was too extensive to use surface or intrinsic radium therapy as the main form of treatment. We therefore used protracted roentgen therapy, as previously outlined, up to the point of tissue tolerance, and supplemented this in a few cases with radon implants. There were 7 cases of lingual carcinoma, all of which extended either anteriorly into the sublingual space or laterally into the alveolus. One patient had a pathological fracture and 3 others showed destructive lesions of the mandible. One patient had been operated upon twice. Another was treated seven years before by local radium therapy. Five patients had lesions of the tonsil and soft palate. Two of the latter had extensions to the buccal mucosa. Three of the above 5 patients

were classified as having embryonal type epitheliomas, 2 had adult type squamous epitheliomas. In this group of 12 cases, 2 patients are alive without signs of disease for thirty-four months and one for thirteen months. Another patient is living fourteen months after treatment but he has a necrosis of the mandible which may be malignant. In one of the patients alive thirty-four months after treatment, the uvula was removed four months after roentgen therapy and disease was present. Several months later a swelling in the posterior pharyngeal wall was implanted with radon seeds. No necrosis resulted in spite of the heavy external irradiation. The other case (sublingual) which is alive and without signs of disease for thirty-four months had only external irradiation. Another patient in this group who had a smaller but a similarly situated neoplasm of the same histological type failed to respond in spite of a larger dose of roentgen radiation which was followed by radium therapy. These cases illustrate the difficulty in making a prognosis from the size of the lesion, anatomical site and the histological configuration of the biopsy specimen.

It is our feeling that external irradiation alone cannot control the majority of extensive intraoral malignancies, especially those arising in the tongue and which infiltrate bone or which extend widely into the contiguous soft parts. Intrinsic radium therapy must be used in addition in certain cases. Surgical endothermy may also be of value. Whether greater protraction of the time from forty to ninety days may be of value can only be determined by further study.

Group II: The second group consists of 14 patients who had carcinoma of the larynx (extrinsic and intrinsic). Although a few patients of this group may have been operated upon primarily, complicating organic disease, cerebral arteriosclerosis, aneurysm of the aorta, marked cachexia and pulmonary tuberculosis made this impossible in 4 cases. The extent of the lesion made surgery impossible in a few others. Two patients refused operation. The immediate response in most of the cases was favorable and palliation was obtained even in those where recurrence occurred. No patient required a tracheotomy after treatment was begun. There have been neither pulmonary nor general complications nor late radionecroses up to the present time. Only cases treated prior to May, 1933, are presented.

Comment on Table III. Case 1 was treated atypically because we were still uncertain how far we might go with our dosage. In spite of this long treatment period he is well three and a half years after treatment. Another significant point is the fact that the lesion arose from the true cord and this is generally considered as a radioresistant type. This fact and the small total dosage again indicates the difficulty in making hard and fast rules in the treatment of carcinoma.

Case 2 showed involvement of the pyriform sinus and probably the cartilage. He was treated too rapidly and retreatment was of no value.

Case 3 was in such poor nutrition and was so weak that adequate treatment, such as we should give today, was impossible. All efforts to improve his general state were futile in spite of hospitalization. He died of erysipelas five months after admission.

Case 4 presented a problem similar to Case 3.

Cases 5 and 6 responded favorably to treatment.

Case 7 is of extreme interest. In 1920 a local removal of a sarcocarcinoma posterior to the right true cord was done by suspension laryngoscopy. In June, 1932, there was hoarseness, and examination revealed a local recurrence. Laryngectomy was refused. Roentgen examination showed invasion of the cartilage and therefore roentgen therapy was not advised. The lesion was exposed by laryngotomy. The tumor was partially removed and tracheotomy was done. No involvement of cartilage was found at operation. Roentgen therapy was then given. The tracheotomy tube was removed and at present there are no signs of disease.

Case 8 shows a good response in a patient with advanced arteriosclerosis.

Case 9 had a most extensive lesion extending

TABLE III

INTRINSIC AND EXTRINSIC PRIMARY CARCINOMAS OF THE LARYNX

		r with back-scattering	Results
Case 1. M.T. Age 53 3-11-31†	Squamous ca. Vocal cord; gland—	Right 2,100 71* Left 2,100 days Post. 900	No signs Sept., 1934
Case 2. A.A. Age 69 10-23-31	Squamous ca. Base of tongue, vallecula, epiglottis, right true and false cord	Right 3,000 16 Left 2,400 days Right 31200 Left 1,600	Temporary local healing 8-5-32 Last follow-up disease present
Case 3. J.P. Age 50 10-15-31	Squamous ca. Base of tongue	Right 2,431 75 Left 2,466 days	Deceased 3-26-32 Erysipelas
Case 4. M.D. Age 66 10-28-30	Squamous ca. Left pyriform fossa	Right 800 53 Left 1,700 days Gastrostomy	Deceased 2-4-31 Very advanced poor nutrition
Case 5. B.G. Age 40 1-30-32	Squamous ca. Epiglottis	Right 2,700 25 Left 2,800 days Ant. 1,000	No signs Sept., 1934
Case 6. J.L. Age 58 5-6-32	Squamous ca. Right vocal cord	Right 3,100 25 Left 3,000 days Ant. 400 Post. 500	No signs Sept., 1934
Case 7. M.M. Age 53 6-14-32	Squamous ca. Recurrent ventricle and false cord P.O.	Right 2,600 29 Left 2,675 days Ant. 1,000	No signs Sept., 1934
Case 8. M.S. Age 66 10-21-32	Immature squamous ca. Epiglottis	Right 2,900 31 Left 3,000 days Ant. 600 Post. 300	No signs Sept., 1934
Case 9. D.B. Age 55 6-4-32	Squamous ca. Epiglottis to right true cord	Right 2,855 54 Left 2,880 days Post. 345	Deceased 6-30-33 Laryngectomy 1-28-33
Case 10 C.M. Age 60 9-23-32	Squamous ca. Right vocal cord	Right 3,050 33 Left 3,150 days Ant. 600	Recurrence July, 1933 Laryngectomy
Case 11 M.D. Age 48 2-6-33	Squamous ca. Right cord	Right 3,800 30 Left 3,600 days Ant. 1,800	No signs Sept., 1934
Case 12. A.P. Age 62 3-22-33	Squamous ca. Hypopharynx	Right 2,550 24 Left 2,800 days Post. 2,800	Deceased Sept., 1933
Case 13. M.Z. 4-10-33	Squamous ca. Right cord	Right 3,785 30 Left 3,750 days Ant. 450 Post. 200	Local recurrence Deceased Sept., 1933
Case 14. G.B. Age 48 4-25-33	Squamous ca. Epiglottis base of tongue	Tracheotomy Right 4,300 32 Left 4,300 days	No signs Sept., 1934

* Number of days on chart indicate duration of roentgen treatment.
† Date of admission.

from the epiglottis to the true cord. He was treated sporadically and inadequately. This was partly due to the patient's lack of cooperation. A residuum always remained after treatment. There was definite delay in the healing after laryngectomy but there was no gross necrosis. Healing was complete in about six weeks. The patient died one year after admission of local recurrence.

Case 10 was also underdosed, in view of our later experience. In fact, there is still a question whether the adult type of squamous cancer arising on the true cord should be treated by radiation or whether laryngectomy is more advisable, especially in those cases where local removal is impossible by the laryngofissure approach. There was a local recurrence ten months after the roentgen treatment. Laryngectomy was done. There was some delay in healing after laryngectomy, but there was no gross necrosis. He is well and completely healed now.

Case 11 showed a good response.

Case 12 showed only symptomatic relief for a short time. I believe that the hypopharynx cases are more radioresistant than the other types shown and I believe that larger doses and more protraction of the number of days of treatment is necessary.

Case 13 had an extensive lesion arising on the true cord and he was advised to have a laryngectomy which he refused. Although the early response was good, recurrence was noted five months after treatment and he died soon after.

Case 14 came to the hospital in marked dyspnea and distress. Tracheotomy was done and after one week, treatment was begun. The response was good and two months after admission the tracheotomy tube was removed. There are no signs of disease at present.

In brief, it may be stated that a large percentage of intrinsic and extrinsic laryngeal malignancies, except some arising on the true cords or in the hypopharynx respond favorably to irradiation. Late radionecroses have not occurred thus far. Infiltration in the muscles and cartilage modifies the response. Whether the latter will respond by a change in technique can be determined only by further experience. At present it is probably safer to operate on the true cord tumors whenever possible. Experience with various irradiation techniques may be had in those patients who refuse operation and in those who are inoperable because of some organic disease. At present there are no criteria to guide us in differentiating between those true cord tumors which will or will not respond to external irradiation. We do know that when the cord is fixed, the response is usually poor.

Naturally, the question arises in reviewing the favorable response of these tumors as to the reason for our so-called success. I believe that it is due to the following: (1) relative radiosensitivity of the tumors which cannot always be predetermined; (2) small size of tumor making small portals of entry possible; (3) relatively short distance of tumor from the surface of the body; (4) use of crossfire; (5) large depth dose that is made possible without permanent damage to the healthy tissue because of the factors above mentioned.

In the group of cases which we recognize at the outset as belonging to the more radioresistant variety, because of the anatomical site, histological type and because of invasion of muscle and bone cartilage, a different technique should be considered. Coutard advises greater protraction of the time forty to ninety days. If this is done, the usual mucous membrane reaction (radioepithelitis) is minimal and the same is true of the skin reaction (radiodermatitis). Thus far, I have had no personal experience with this method of greater protraction but I think that it should be tried.

SUMMARY

1. Twenty-six cases of extensive intraoral and laryngeal carcinomas were treated by protracted roentgen irradiation according to the principles of Coutard.

2. Whether comparable results can be obtained by higher milliamperage technique and by the use of a filter of 0.5 mm. Cu can be determined only by further experience. We believe that there are fewer complications during the treatment and less damage to the healthy tissue by the

use of a heavier filter and lower milliamperage.

3. By using portals of 100–150 sq. cm. a filter of 2 mm. Cu with 200 kv. and a rate of 3–5 r per minute, 3,000–3,600 r measured with back-scattering may be given to some patients if protracted daily over a period of twenty-five to thirty-two days. A maximum of 4,200 r has been used in several cases. Two such fields may be used to crossfire a neck.

4. The use of the above factors has given us favorable results in malignancies of the intrinsic and extrinsic larynx.

5. The use of external irradiation alone, such as we gave until recently, is not usually sufficient to eradicate extensive intraoral malignancies.

6. Following a course of protracted roentgen therapy, two laryngectomies and supplementary implantation of radon seeds in three of the intraoral carcinoma cases have been done without radionecroses.

7. Meticulous care in the installation of the apparatus and good medical care before and during the treatment are requisites for good results.

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DISCUSSION

Dr. William H. Meyer, New York City. Such work as that of Dr. Harris is distinctly valuable because of its consistency of effort. It is by such persistency that facts are evolved and truth clarified.

Radiation therapy as applied today is a most complex and difficult subject since there are so many interdependent factors involved. The coordination between the technical factors and the physical dose measurements in relation to the biological reaction in tissues of varying radiosensitivity remains a difficult problem.

Another important point from the legal, as well as the medical aspect, is the effect on the skin, when intensive radiation therapy is applied.

One might well ask whether the severe skin reactions are justified by the results obtained by radiation therapy in deep-seated malignancy. It is also still open to question whether the cumulative, saturation or Coutard method produces results superior to the unit massive dose, providing quantitative similarity be established.

No definite interrelation has as yet been determined between the gross sum of physically measured roentgens, whether fractional, interval or continuously administered; the supposed net cumulative r wherein a given allowance for decadence is made, and the biologically effective dose in roentgens. In truth the number of r as quoted today means little from the biological standpoint. Immediate progress would appear to depend upon a clearer concept of qualitative and quantitative dose measurement in relation to tissue reaction.

Furthermore, any scheme that affords increased depth dose with increased skin protection is worthy of careful consideration.

As radiation therapy today is but an evolution of previous methods, so has the protective grid that we employ for increased skin protection been evolved from a suggestion made by Köhler as early as 1909, wherein he stated that several erythema doses could be applied through a wire mesh since the mesh affords circumferential strips of relatively little damaged skin around the islands of maximal radiation.

Perhaps you will pardon my own persistency of purpose in stating that more than twenty years ago, I designed a special grid and reported on its construction and use in 1917. More recently we have put this mesh to use as a *fixed grid* and with continuous massive dosage (applying up to six times an erythema dose), appear to obtain as satisfactory results in deep-seated lesions with no more skin damage than results from the Coutard or any other heavy cumulative dose method.

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OUR CHANGING CONCEPTS REGARDING THE SKIN DOSE*

WITH SOME NOTES ON THE PRODUCTION OF EPIDERMOLYSIS

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RECENT literature on the application of external irradiation is so filled with discussions of the total dosage, the use of various thicknesses and combinations of filters and the merits of protracting the dose, etc., as exemplified in the Coutard technique, that such terms, without the more serious consideration of their significance often seem to lead us astray from the more fundamental principles involved. Under this same influence a gradual change in the concept of skin reactions produced in radiation practice has taken place so that today many radiologists are applying heavier doses to the skin than ever before deemed safe or possible.

A brief résumé of the historical development in the light of present knowledge will probably best exemplify the foregoing.

From earliest times, fractionating of the total dose took a prominent place, especially in early American radiological practice. However, under the stimulus of the work of Wintz and Seitz, the massive dose technique with its single "cancericidal" dose of radiation soon assumed prominence. Such a dose, in the light of our present knowledge, was approximately 750 to 800 r primary radiation with 0.16 Å λ eff. at 200 kv. On account of the limitation of the number of patients that could be treated, the marked radiation sickness encountered, and the constant fear of skin damage, this technique never became universally popular and today is commonly restricted to the treatment of small superficial malignancies.

Following this there was a reversion to the fractionating concept, with the resulting popularization of the "divided dose method," which we now recognize as consisting essentially of three or more fractionated treatments of the above mentioned radiation quality. With this method it is customary to give 880 r primary radiation in two days, 960 r in five days, 1,040 r in eight days, 1,120 r in ten days or 1,200 r in fifteen days. When tissue recovery was computed on the above doses it was noted that the resulting skin reaction at the end of the treatment was approximately that of an 800 r effective dose as in the massive dose technique. Thus by almost common consent the 800 r dose came into general usage as the so-called "therapeutic erythema dose."[7]

The idea of prolonging the total irradiation effect over some time gave rise to the "saturation method" of Pfahler. This method presupposed a rather rapid building up in three or more larger increments over eight to ten days of a total effective or cumulative dose in the skin of 800 r or less primary radiation, much as in the divided technique, but here this effective dose in the skin was maintained at this figure by weekly or bi-weekly additional increments of primary radiation computed on the basis of tissue recovery so as to assure a saturation effective of 800 r primary radiation in the skin over a period of four to six weeks.[9]

It will be noted that all three of the foregoing techniques developed around this same skin reaction of 800 r primary radiation. This reaction should be carefully distinguished from the "threshold erythema" or biological erythema fixed by Martin and Quimby[6] at 525 r primary radiation, which is the amount of radiation necessary to produce a just appreciable reddening of the skin in 80 per cent of patients and is

* From the State Institute for the Study of Malignant Diseases, Buffalo, New York, Burton T. Simpson, M.D., Director. Read at the Thirty-fifth Annual Meeting, American Roentgen Ray Society, Pittsburgh, Pa., Sept. 25–28, 1934.

approximately two-thirds of the former therapeutic erythema dose. This later was advanced more as a minimal biological skin unit than as a standard for dosage and should not be so confused.

Regaud[10] with the teleradium pack therapy which is essentially the equivalent of a low r/min. output, approximately 4 r/min. as measured by the Victoreen dosimeter, had developed the technique of administering daily treatments of what approximates 300 r under present standards, carried to a total of 3,500 to 5,000 r in ten days to two weeks. This pack technique produced a more intense skin reaction, rerecovery from which was rapid and complete. To this reaction the French school gave the name of epidermolysis. Coutard,[3] also from the Curie Institute, attempted to achieve similar results with roentgen radiation. His treatment technique, as later reported, consisted of an attenuated intensity of 5 r/min., giving 250 to 300 r daily for twelve or more treatments, spread over two weeks or longer, with a total of 5,000 to 6,000 r, tissue measured, at 200 kv. with a λ eff. of approximately 0.11 Å. This will be noted as a fair imitation of the pack technique. The Coutard technique also produced an epidermolysis with apparently a quite similar efficacious effect upon the malignancy.[8] Publication of the details of this technique followed a considerable time after the more enthusiastic report of results by Coutard with the consequence that many modifications arose gleaned from what various radiologists interpreted his method to be. It has ultimately turned out that many of these various modifications now serve to throw added light on this newer concept of epidermolysis which, in the final analysis, proves to be the result of a higher cumulative effective r dose in the skin produced by a technique which will more gradually over two or three weeks bring the skin and other tissues up to a higher saturation point, approximately 2,000 r primary radiation as computed

Table I

ESTIMATED PRIMARY r FOR VARIOUS SKIN REACTIONS AND THEIR RATIOS COMPARED TO THE THRESHOLD ERYTHEMA

Reactions	X-Ray				Radium	
	λ Eff .16 Å .08 T.R. Co-eff	Ratio	λ Eff .11 Å .06+T.R. Co-eff	Ratio	λ Eff .017 Å .04 T.R. Co-eff	Ratio
Threshold erythema	525 r 65.6%	1	755 r 65.6%	1	1600 r 65.6%	1
Therapeutic erythema	800 r 100%	1.5	1200 r 100%	1.5	2400 r 100%	1.5
Epidermolytic reaction	1300 r 165%	2.5	2000 r 165%	2.5	4000 r	2.5
Necrotizing reaction	1500 r 178%	2.9				
T.R. Co-eff = Tissue Recovery Co-efficient						

Values are given in r measured in air to avoid the controversy now being waged over the accuracy of r values reported with tissue scattering. Anyone wishing to transform such figures into "tissue scattered values" can do so for roentgen rays by applying a 40 or 45 per cent addition according to the usually computed tissue scattering values for the specific wave length used.

from our experience on the basis of 0.06+ daily tissue recovery coefficient.

Of these modifications, one of the most popular seems to be that practiced with the lighter filtration of 0.5 mm. copper at 200 kv., thus developing a 0.16 Å λ eff. Such a technique is used at the Radiumhemmet, by Borak, by Fried at the Holfelder Clinic, at the Memorial Hospital in New York, by the Harvard Cancer Commission and by ourselves at the State Institute. It is now our usual practice to produce an epidermolytic reaction by delivering 280 r primary radiation of the above type seven times over eight days on a single field at a 50 cm. skin target distance, or for approximately eighteen to twenty times over opposite fields in three weeks. The resulting skin reaction can be varied from an epidermitis sicca to that of an epidermitis exudativa, depending on the size and number of the daily increments administered. It differs in no essential from that produced by the teleradium pack or by the typical Coutard technique with the usual 2 to 3 mm. copper filter.

The essential principles embodied in the Coutard technique may be conveniently enumerated as (1) the production of epidermolysis by (2) protraction or low r/min. rate with (3) heavy filtration and (4) fractionating of the dose in small daily optimum increments. We will now proceed to analyze briefly these factors.

The production of the epidermolytic reaction presupposes an almost complete destruction of the epidermal layers leaving a relatively intact dermis with its vascular and connective tissue elements. This is followed in forty to fifty days after the beginning of treatment by complete restitution through regeneration of the basal layer of cells, some of which have usually survived in islets about the hair follicles and near the edge of the irradiated area. This reaction is thus practically the second degree burn of the older technique and was commonly supposed only to be produced by protraction, fractionating and heavy filtration, as exemplified in the Coutard technique. At the Institute we have more recently succeeded in producing typical examples of this reaction by a single dose of 3,000 r, tissue measured, or 2,000 r primary roentgen radiation at 23 r/min. rate and 0.11 Å λ eff. (3 mm. copper), thus entirely eliminating both protraction and fractionating in the production. Such reactions reached their height in about a month after treatment and subsided in another three to four weeks.

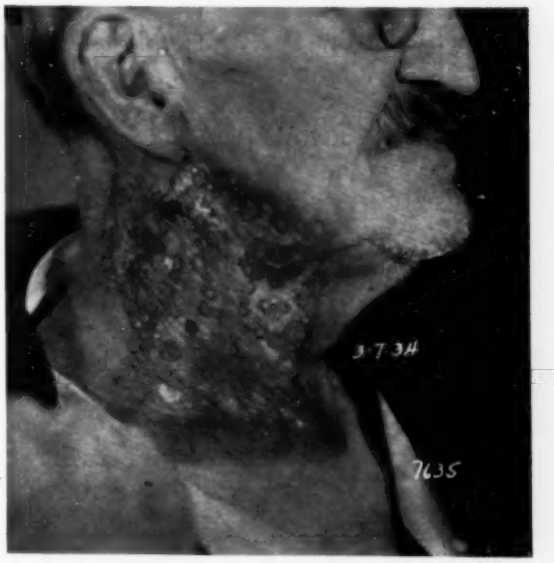

Fig. 1. The epidermolytic skin reaction produced by a single dose of approximately 2,000 r (measured in air) with 200 kv., through a Thoraeus filter of 3 mm. copper equivalent, at a 23.6 r/min. rate and an effective wave length of 0.11 Å. This reaction went through the usual evolution, being preceded by the typical mucositis, and completely healing in fifty-five days leaving a healthy skin.

Similarly with 0.16 Å λ eff. in a single dose of 1,850 r, tissue measured, or 1,280 r primary radiation at 65 r/min. rate, a marked redness followed by severe vesiculation and accompanied by the usual epithelitis of the mucosa was produced. A number of single doses of 1,200 r have likewise been given on neck fields without provoking reactions much beyond moderate redness, some vesiculation and pigmentation. As such doses are probably very close to the maximum tolerance doses which the

skin may stand, they should not be used as therapeutic procedures but only as experimental means in studying such problems.

Let us next view this newer skin reaction in the light of the exponential law of mass reaction for tissue recovery to roentgen radiation as first enunciated by Kingery for unfiltered radiation and later computed for 0.16 Å λ eff. wave length roentgen rays independently by Pfahler, Hirsch, and Stenström and Mattick. Daily tissue recovery coefficients varying from 0.04 to 0.08 have been calculated by these writers, that of 0.08 by Stenström and Mattick[12] being the highest. Considerable work in this field has also been done by Weatherwax,[13] who has also deduced a recovery coefficient for the gamma rays. Analyzing these epidermolytic reactions as produced by the Coutard or modified techniques in the light of this daily tissue recovery coefficient of 0.06+ as assumed by us for the 0.11 Å λ eff. wave band or by the coefficient of 0.08 for the 0.16 Å λ eff. wave band as used in the modification techniques, a skin saturation effective of approximately 2,000 r is arrived at for the heavier filtration with the 0.11 Å λ eff. band and 1,300 r for the lighter 0.5 mm. copper band. This closely links our experimental results from massive single doses, as cited above, with those of the Coutard and modification techniques when this daily depreciation of irradiation effect in tissue or, as it is more commonly called, the tissue recovery, is duly considered.

Let us next deal with the question of protraction or its equivalent, diminished r/min. intensity, which is most easily effected by increasing the skin target distance or reducing the milliampere output through the tube. Preferential r/min. rates of various radiologists for this type of work vary from 4 r/min. as used by Coutard, through 20 r/min. as used as Borak and 40 r/min. as used at the Holfelder Clinic. At the Institute this rate has gradually been increased from 4 r/min. to 65 r/min. with no observed difference in results. Chaoul[2] reports first noticing a lessening of intensity of the skin reactions produced only when the attenuation of this r/min. rate fell below 1:16 which as noted corresponds favorably with our experience. We do not feel, therefore, that this factor is very essential within the above limits, although the Coutard claim of a more selective effect on the tumor as well as a lessened damage to the surrounding normal tissues should be carefully considered.

Heavy filtration with the resulting lesser absorption of the radiation by the tissues has always been recognized as a useful safeguard against tissue damage. We have experimented with filtrations varying from 1 mm. lead up to 3 mm. copper, including the Thoraeus combinations, in the production of roentgen erythemas. Some of the reactions with 0.5 mm. copper at 200 kv., 65 r/min. rate and 50 cm. skin target distance developing the resulting 0.16 Å λ eff. will be shown in contention of our claims in conjunction with those of Fried,[4] Berven, Borak,[1] and others, as to the production of epidermolysis similar to that of Coutard by this lighter filtration. These reactions differ in no essential from those resulting from the heavier filtration and have the added advantage of being produced under the more usual radiation conditions by simply applying daily fractionating and building up in proper increments at 50 cm. skin target distance to approximately 1,300 r skin effective saturation or 1,960 r tissue measured radiation in eight days. If alternate neck fields are treated every other day for approximately twenty doses over three weeks, then it is necessary to go as high as 3,000 to 3,500 r primary radiation on each field to build up to 1,300 r saturation effective. This may seem like high total dosage but it should be reiterated that the production of the necessary effective saturation or cumulative dose in accordance with the effective wave length of the radiation used is of paramount importance no matter to what limits these total dosage figures may be carried. Such total dosage figures are therefore of little importance unless accompanied by other factors, such as total time over which the treatments

are carried, daily dose in r, quality of the beam, etc.

Of all the principles involved in the Coutard technique probably that of fractionating may be generally conceded as being of prime importance in the practical production of epidermolysis. Although at the Institute we have produced the reaction by massive single doses, we would advise that this procedure is unsafe as a routine, especially on account of the more noticeable occurrence of idiosyncrasies in patients carried to these higher skin reactions. It is further necessary that an optimum daily fractionated dose be chosen so as to produce the desired effective skin saturation point within the time of application of the radiation treatments if epidermolysis is to be expected. Such choice can be assured by making use of the daily recovery coefficient and the effective saturation skin dose selected in accordance with the effective wave length used. Holthusen[5] states that protracted fractional doses not only enhance the harmful effects on the tumor with less injury to the normal surrounding vascular tissues but that this epidermolytic reaction can be more safely produced by such methods. All radiological clinics both in this country and abroad seem to cling to this daily fractionating principle as a means of avoiding skin damage, thus attesting to its apparent significance in the production of these more intense reactions. Experimental proof in favor of fractionating is not lacking. Ferroux, Nijka and Regaud found that regression following a single dose on the Brown-Pearce rabbit carcinoma was only attained at the expense of skin damage, whereas with five fractionated doses over nine days of 4,500 R (Solomon) total radiation caused in 2 cases complete disappearance of the tumor which lasted over ten months. Nather and Schinz also observed that 4 to 7 S.E.D. on transplanted mouse tumors in a massive single dose did not cause regression, whereas after six fractions of 2.5 S.E.D. each, or 15 S.E.D., complete disappearance was effected.

It may be well to repeat that in conjunction with fractionating in the production of the epidermolytic reactions much care must be exercised to assure the proper optimum daily dose. All patients undergoing such treatments should also be carefully advised against missing any of the daily treatments. Non-observance of the two latter points often causes a failure to gain the therapeutic result desired, as the effective dose in the skin and tissues may never accumulate high enough to produce these more intense reactions.

It is further probable that the normal growth rhythm of the body cell may play some part in the resultant skin and tissue reactions. Thus Glocker, Langendorff and Reuf working with bean roots have shown that by dividing the dose in two equal parts and administering these parts at the time of minimum mitosis they could produce a damage equivalent to an effect from a 25 per cent lesser single dose than if administered at the time of maximum mitosis at which time the damage was approximately the equivalent of that produced by a whole massive dose. Reinhard and Tucker have also previously reported a similar periodicity of radiation effectiveness in the root tips of *Vicia faba* seedlings.

In conclusion it should be emphasized that:

(1) The past decade has witnessed a gradual change in our concept of the skin dose from the former therapeutic erythema produced by 800 r primary radiation at 0.16 Å λ eff. to the newer epidermolytic dose which, according to our experience at the Institute, is approximately 65 per cent higher than the former reaction, and approaches more closely the maximum skin tolerance.

(2) This epidermolytic dose is most usually and safely produced by a series of fractionated optimum daily increments, so chosen as to build up and form a saturation effective or cumulative dose of approximately 1,300 r for the 0.16 Å λ eff. and 2,000 r for the 0.11 Å λ eff. beam at 200 kv. The effective r dose becomes therefore

the important consideration in this type of therapy.

(3) It is apparently purely optional whether we use a heavy 3 mm. copper filter or the ordinary 0.5 mm. copper filter in the production of this epidermolytic reaction.

(4) This reaction can be attained by one massive dose but this is not advised except for experimentation.

(5) The number of daily treatments depend on the size of the daily optimum dose chosen to build up the effective saturation desired in the skin.

(6) Protraction or diminished r/min. intensity while a safeguard in attaining these ends is not a necessity within the ordinary limits herein cited.

(7) The total r dose as often reported has little or no significance, is often confusing and should be omitted unless the duration of the treatment time in days, the optimum daily increment in r, the effective wave length, and the cumulative or effective primary r dose in the skin are also given.

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DISCUSSION

Dr. James J. Duffy, New York City. It is not necessary to go beyond the title of Dr. Mattick's paper to get material for a great deal of thought and for speculation. I believe that his title is not only a review of the past,—it is a prophecy. It is my firm belief that we are passing through a phase of enthusiasm for the so-called Courtard method that will again change our conception of a skin erythema. If it is necessary to produce such a degree of destruction of normal tissue to attain slightly better statistical results, I do not now believe that we shall be gratified with the five year survival figures. Even if these may be a bit better, they will have been attained at too great cost in pain and discomfort to the non-surviving group, and possibly at too great a cost of life. Many patients are unable to withstand such radical irradiation.

It is not my intention to deprecate heavy external irradiation altogether. There are those regions of the body which do not tolerate interstitial radon. I might mention a few locations, namely, the intrinsic and extrinsic larynx, the hypopharynx and base of tongue and the nasopharynx. To these regions may be added the tonsil if the lesion is the very malignant type, as lympho-epithelioma or transitional carcinoma. But even if we persist in the use of the protracted and very heavy irradiation, I believe we should make use of only the shortest wave lengths that are now reasonably possible, and discontinue the 0.5 mm. of copper now so widely used. The shorter waves would not only

give a better depth dosage, but what seems to me at least as important, they are probably more selective in their action.

In the oral regions other than I have mentioned, I believe that we should continue to use buried radon following less severe external irradiation. Most of the lesions are the more radioresistant type, usually Grade II, and need some interstitial radon to eradicate the residual disease, following the protracted, severe external irradiation. I believe the final results will be better, and with less suffering in successful as well as unsuccessful cases, if we give more moderate external treatment, and slightly greater dosage of interstitial radon.

Dr. Mattick has mentioned a subject which has been especially interesting to me, namely, tissue recovery following irradiation. Some time ago I did some experimental work along this line with Dr. Voke and Dr. Arneson. The report is now in press. A résumé here should be of interest.

The extensor surface of the forearm was chosen to ascertain the threshold erythema dose. This, as you know, is that amount of radiation which will produce an appreciable discoloration in 80 per cent of the cases, and no change in 20 per cent, in two to four weeks following exposure. The threshold erythema dose, at 200 kv., with 0.5 mm. Cu filtration at 50 cm. skin target distance, was 525 r, measured in air. Then the dose was divided into two equal amounts, given at a twenty-four hour interval, increasing the amount of each until a threshold reaction was obtained. Four hundred roentgens at each exposure was required to produce an appreciable discoloration in 80 per cent of the tests. When the interval between exposures was forty-eight hours, it required 425 r at each exposure to produce a threshold erythema. It is reasonable to assume that the effect of the two doses of radiation was due to the effect of the second exposure added to the residual effect of the first exposure. Therefore, the skin recovery in twenty-four hours was 69 per cent, and in forty-eight hours it was 76 per cent. I shall not give the details of the process by which these figures were obtained, because these can be found, by those interested, in an early number of *Radiology*.

RADIUM TREATMENT OF CANCER OF THE RECTUM*

By WILLIAM M. SHEDDEN, M.D.
BOSTON, MASSACHUSETTS

FOUR years ago there was read before this Society a paper by Bowing and his associates dealing with the treatment of cancer of the rectum by radium. In an endeavor to obtain an evaluation of the present status of irradiation as applied to malignant growths in this region, I have thought it worth while to review the literature since 1930 and to report cases of cancer of the rectum treated at the Huntington and Palmer Memorial Hospitals in Boston.†

It is well recognized that a large majority of rectal cancers are of the glandular type. It is perhaps not as well appreciated that rectal adenocarcinoma, though resistant, is not insensitive to irradiation but varies greatly in its response. Doses very close to the margin of tolerance of healthy tissue are required and an overdose almost always results in necrosis and consequent sepsis even though the beta rays are practically eliminated.

We must remember that radiation therapy has only been applied to rectal cancer for little more than a decade, while surgery has been employed in this field for over a century; secondly, that irradiation occasionally produces a clinical cure of many years' duration. The successful cases, however, form such a small percentage of the total treated that we are all as yet duty bound to advise correct surgical excision in preference to radium in those cases in which there is a reasonable prospect of success.

We must recall, however, that a similar statement was true for cases of buccal cancer about six or eight years ago. It is, therefore, not unreasonable to believe that with the advancement of knowledge and with improved technique, our position may be altered within the next few years. We are justified now in using radiation therapy in the case of the patient who is locally operable but who refuses surgery, who for some constitutional reason is not a good surgical risk or, finally, who is frankly inoperable.

The treatment of cancer of the rectum with radium must be modified to the needs of the patient. The following factors need consideration:

1. The patient's ability to stand treatment.
2. The location of the tumor.
3. The extent of the disease.
4. Degrees of malignancy, infection and radiosensitivity.

The correct method of treating cancer of the rectum with radium is yet to be determined. Gordon-Watson declares that although he has treated over 500 cases, he still requires more experience before he can express a definite opinion as to the methods which should be adopted.

The criteria of a correct dose are:

1. Rapid resolution of growth.
2. Restoration of normal epithelium.
3. Limited fibrosis.

The successful irradiation of any individual case lies in:

1. The correct assessment of the amount of radium required.
2. The method of distribution.
3. The time it should be left in.
4. The amount of filtration that should be required to secure gamma radiation.
5. The prevention of sepsis or necrosis from beta radiation or excessive gamma radiation.
6. The protection of adjacent healthy tissue.

Factors which influence the dose:

1. Excessive vascularity or fibrosis.
2. Proliferation or ulceration.
3. Other as yet unknown biological factors which may increase or diminish radiosensitivity.
4. The line of lymphatic spread.

† I wish to thank Dr. Channing C. Simmons, Chief Surgeon of the Huntington Memorial Hospital, and Dr. Leland S. McKittrick, Chief Surgeon of the Palmer Memorial Hospital for permission to report these cases.

* Read at the Nineteenth Annual Meeting, American Radium Society, Cleveland, Ohio, June 11–12, 1934.

Result of dosage:

1. Optimum dose: destruction and repair without appreciable deformity.
2. Excessive dose: stricture and stenosis.
3. Inadequate dose: regression and subsequent activity.
4. Radioresistant tumor: practically no response.

4. Irradiation via the vagina.
5. Perirectal radium needle puncture through the skin.
6. Distant "bomb" therapy.
7. High voltage roentgen rays.
8. Intra-abdominal irradiation.
9. Any one or a combination of the above plus partial or complete resection of the rectum.

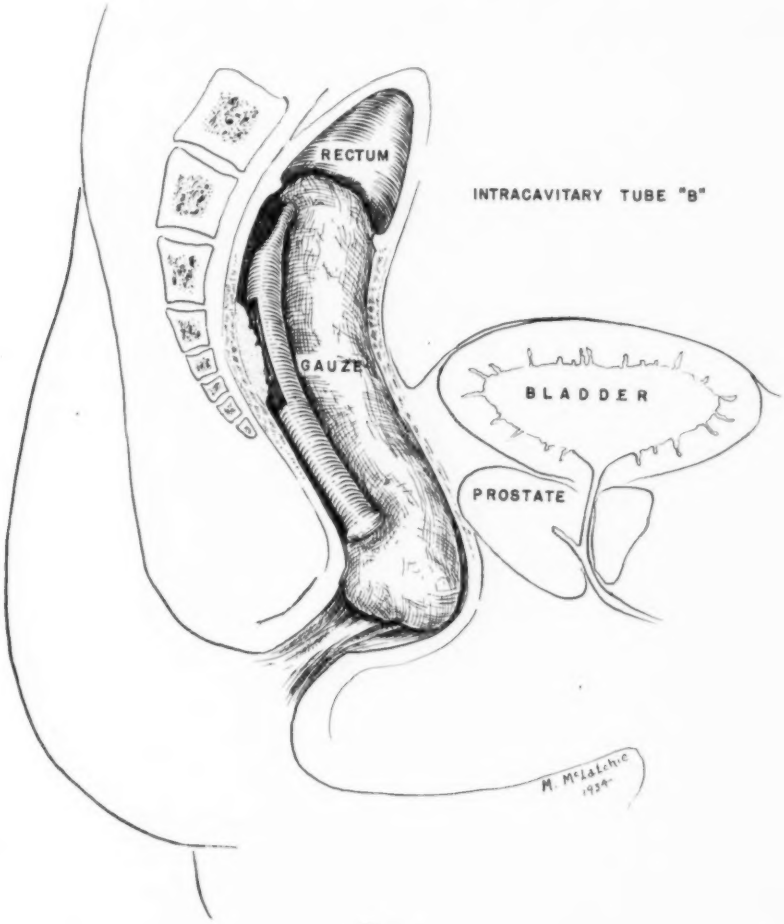

Fig. 1.

Primary irradiation tends to produce an increased degree of radioresistance.

The ideal formula for dosage would be one showing the cubic capacity of the growth, times the number of milligrams of radium, times the number of hours.

The following methods of attack seem worth discussing at the present time:

1. Intracavitary surface irradiation.
2. Intrarectal irradiation with needles or seeds.
3. Barrage by open operation from the perineum.

In the paper just mentioned, Bowing reported two five-year cures following the direct application of radium tubes to the surface of the tumor. The disadvantage of this method is that while a heavy dose of radium is delivered to the surface of the growth, obviously a weak dosage is delivered to the periphery. The intracavitary tube method cures only very rarely, and Coffey was so discouraged with this method that he was led to declare that he would never again use radium in the rectum ex-

cept for some very extraordinary reason.

The implantation of glass emanation tubes via the rectal lumen has the advantage of a more even distribution throughout the tumor but the cautery effect is too severe and the results are too poor to warrant a continuance of this method. Four years ago Hayden and I reported 30 cases thus treated. We found that they lived an average of only three months longer than a similar group with no treatment at all and that their discomfort far outweighed any palliation that the growth might have received.

The next step was to employ emanation seeds filtered with 0.3 mm. gold, and 1 mc. in strength, and imbedded in the tumor via the rectal lumen, with a total dosage of from 10 to 60 mc. It has been our experience that employing six to eight 1 mc. seeds filtered with 0.3 mm. gold will usually give a severe reaction. Abroad they are frequently employing a filtration of 0.6 or even 0.8 mm. in order to screen out further beta radiation. Needles with this filtration are used by Cade at the Westminster Hospital in England. He finds that with this screening there is less necrosis and that the period of irradiation can be increased.

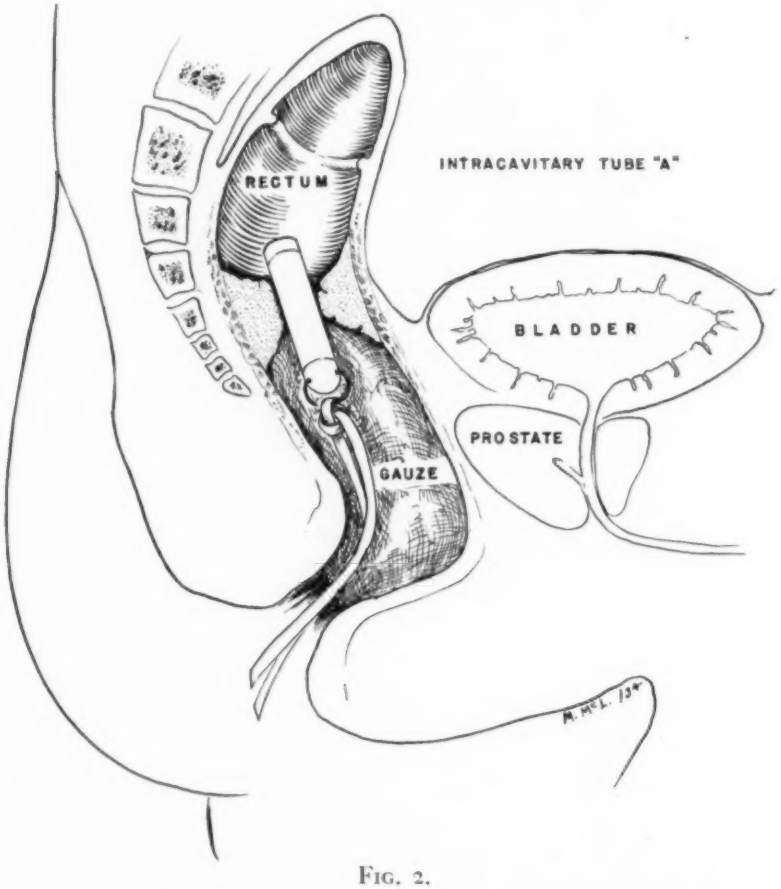

Fig. 2.

Eighty cases were treated by this technique at the Huntington and Palmer Memorial Hospitals in Boston. Of these, 14 were locally operable but received irradiation because their age or general condition contraindicated surgery or because operation was refused. Of the 80, twenty-five as far as can be determined are still living, for periods varying from less than one year to six years, since last treatment.

Of this group there were no five year

cures but there was apparently one three year cure (epidermoid carcinoma) and one four year cure (malignant adenoma).

In 16 cases less than a year has elapsed since the last treatment. The results on those cases are therefore not reported. In 6 cases less than two years has elapsed since the last treatment (one of these is without growth for almost two years). There is one case, living six years, but with a recurrence of growth.

As far as I am able to tell from the hospital records, the group treated with radium plus roentgen radiation did not show any more improvement nor did they live any longer than the group treated with radium alone. With three exceptions, the radium treatment consisted of the intrarectal implantation of gold seeds 1 to 2 mc. in strength and screened with 0.3 mm. gold. Thirty-seven of the total group had colostomies, most of them as a preirradiation measure. There were 10 cases recurrent after radical operation, 5 of these were apparently quite definitely improved by the irradiation. In 4 cases diathermy was added to the irradiation; all 4 were definitely improved.

As to those who received radium alone—it is not until we get 1,000 mc-hr. that improvement is noted. Twenty cases received between 1,000 and 2,000 mc-hr.—6 were definitely improved. Twenty cases received 2,000 to 3,000 mc-hr.—6 were improved (in one instance the local growth was entirely destroyed but the patient died three months later with metastases to the liver). Thirteen cases received 3,000 to 4,000 mc-hr.—3 improved. Nine cases received 4,000 to 5,000 mc-hr.—5 improved. Nine cases received 5,000 to 6,000 mc-hr.—3 improved (one kept entirely symptom-free for more than

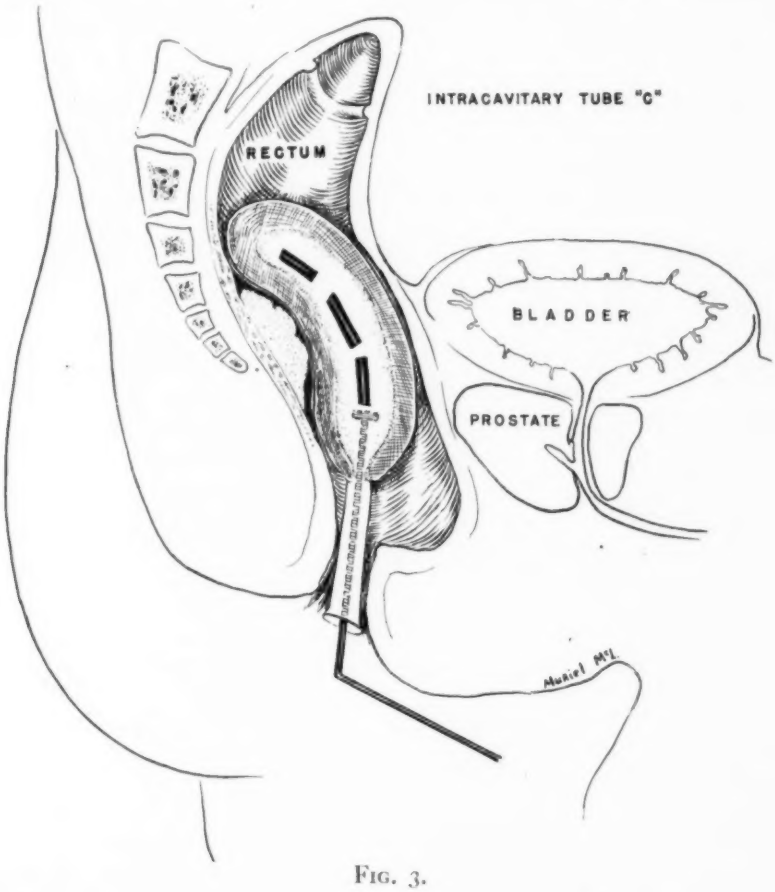

Fig. 3.

three years). Eleven cases received 6,000 to 10,000 mc-hr.—4 improved. The remaining 9 did not have adequate follow-up.

High voltage roentgen treatment was added in 28 cases. Comparing the groups with and without this addition there was no material difference in results.

The high voltage roentgen treatment as used at the Huntington and Palmer Memorial Hospitals is essentially as follows: three portals are employed—one to the front and one to the back of the pelvis and one to the perineum, 1,200 r is delivered at each potal; 190 kv. with a constant potential which equals approximately 215 kv., the distance is 50 cm., and the filtration 0.5 mm. Cu.

Three out of the total group were treated with *radium element* in needles embedded in the tumor via the lumen. One died one and a half years later after a great deal of local improvement. Another showed marked improvement but it is only three months since treatment began. The third had one treatment with a great deal of improvement when seen five months ago.

Both in this country and abroad there has been a gradual change from the use of the intracavitary filtered radium tubes or unfiltered radium seeds to a combination of filtered radium applied interstitially plus high voltage roentgen rays or radium pack or bomb (called telecurie therapy abroad). Some clinics are applying roentgen irradiation plus a radium pack during the same course of treatment. Most of us still feel that the filtered radium seed has a place.

Inspired by the work of Neumann and Coryn, several workers in England and France are applying radium interstitially from the outside of the rectum.

The modified technique of Neumann and Coryn is as follows:

a. An abdominal colostomy is formed.
b. The coccyx is resected after closing the anus and a wide exposure of the rectal ampulla is made through a median incision.
c. Radium element is employed in strengths of

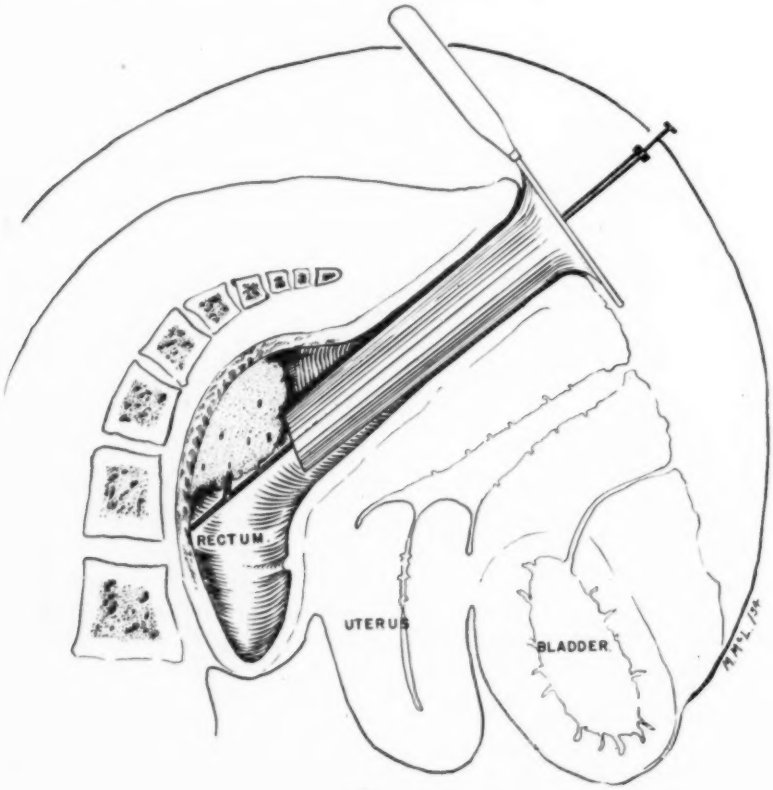

Fig. 4.

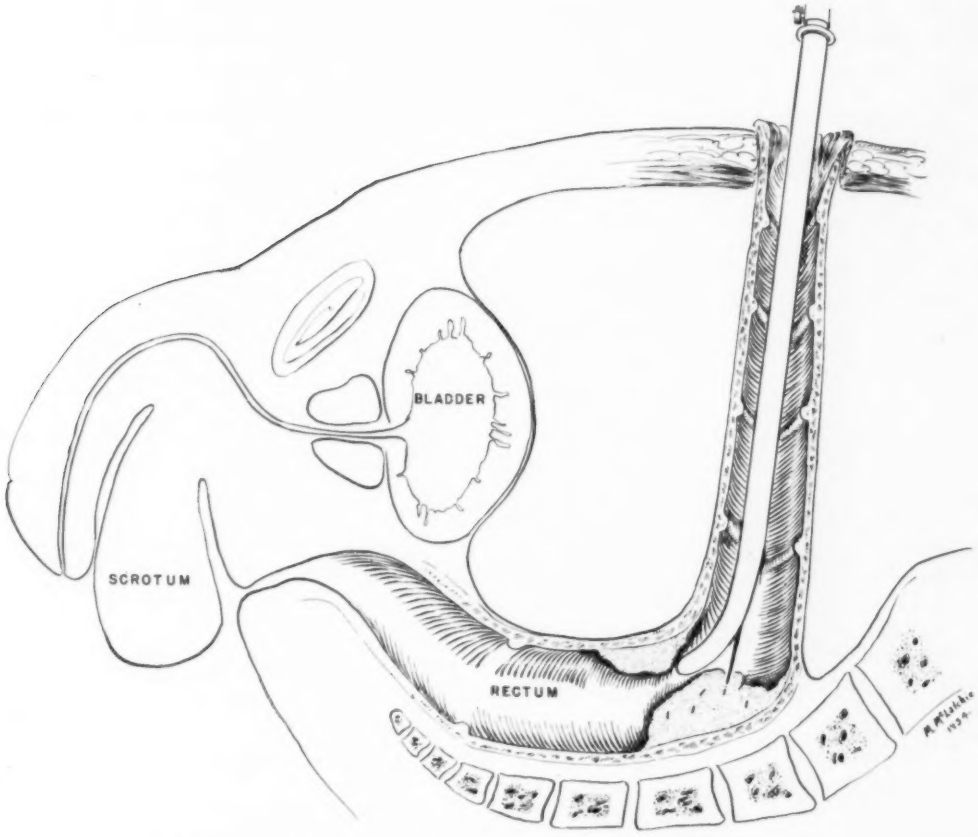

Fig. 5. Implantation of radium seeds via operating cystoscope.

0.5, 1.2, and 3 mg. per needle. The needles vary in length from 1.9 to 6 cm. To secure a uniform radiation, it is desirable that the needles employed in any one case should be all of the same linear intensity; for example 1 mg. per 1.6 cm. of active length. In rectal work it is advisable to employ needles of varying lengths. Long needles are passed along the lines of lymphatic spread; shorter ones may be used to secure uniform and complete barrage of growth. An attempt should be made to deliver 1 mg. of radium to each cubic centimeter of growth. The filtration is 0.5, 0.6 and 0.8 mm. of platinum. Some of the needles are inserted at a tangent to the growth 1.5 to 2 cm. apart and in healthy tissue around the growth; another set of needles is run through the rectal wall from the periphery and into the tumor mass. The needles are placed:

(1) Along the superior and middle hemorrhoidal arteries; along levators and inferior hemorrhoidals.
(2) Above the growth.
(3) Below the growth.
(4) Into the growth.

This may be combined with intracavitary surface irradiation. The average radium exposure is from six to eight days.

d. The rectum may be excised as a fourth step. In females, of course, the growth can be attacked through the vagina.

The contraindications to Neumann and Coryn's technique are as follows: it is painful and the convalescence is very slow; it often causes a chronic urethritis and cystitis.

During the years from 1928 to 1931, Gabriel at St. Mark's Hospital treated 89 cases by the above-mentioned method. They analyzed their series as follows:

1. Carcinoma of the rectum
   1. Operable cases treated with radium 14
      (Most of the figures regarding the treatment of cancer of the rectum with ra-

dium are of very little value as regards cure because it is only rarely that an *operable* case is treated with radium. Gabriel's report is, therefore, very important because it includes these 14 operable cases.)

2. Radium in conjunction with perineal incision 11
3. Intra-abdominal irradiation 16
4. Posterior barrage 9
5. Interstitial needling for inoperable cases 18
6. Recurrent carcinoma 9

2. Carcinoma (squamous) of anus and anal canal 12

Total 89

Analysis of this Group

1. Operable carcinoma (14)
   a—12 treated with radium needles of element. (The anterior rectal wall can be separated from the prostate in the male by inserting lead foil covered with rubber tissue to protect the bladder or urethra. The vagina may be dissected off the rectum as thus there may be less likelihood of producing a recto-vaginal fistula.)
      1—not reported.
      2—alive three years without recurrence.
      3—alive with recurrence.
      6—required subsequent perineal excision.
         4 of these 6 are alive:
            2 years 3 months.
            2 years 3 months.
            6 months.
            3 months after operation.
   b—2 treated with intrarectal radon seeds. The tumors disappeared. Both are recent cases.

Attention is called to three bad results in this group:

1—death from pleurisy and jaundice, three months after interstitial needling.
2—lung metastases 19 months after interstitial needling.
3—death from mediastinal growth 13 months after perineal excision.

It is probable that these unusual catastrophies can be explained only by vascular embolism.

2. Radium in conjunction with perineal excision (11 cases) 3 cases alive and well—3 years, 3 years, and 1½ years.

It was felt at St. Mark's Hospital that the radium was in no way beneficial to these cases.

Binkley urges a more frequent employment of colostomy and perineal resection plus irradiation. He also urges partial surgical removal in inoperable cases plus irradiation. I think we will all agree that the latter method has merit and is worthy of discussion; namely, the one used in inoperable cases, but I do not believe that the colostomy and perineal excision plus irradiation has shown any better results than colostomy and posterior excision alone. Binkley reports 56 per cent (16 cases) of five year cures with this method, but Gabriel reports 54 per cent cures with colostomy and posterior excision alone. Mr. Simford Edwards reports 55 per cent five year cures of colostomy and perineal excision alone and has one case well over twenty years.

3. Abdominal irradiation by radium needles—16 cases.

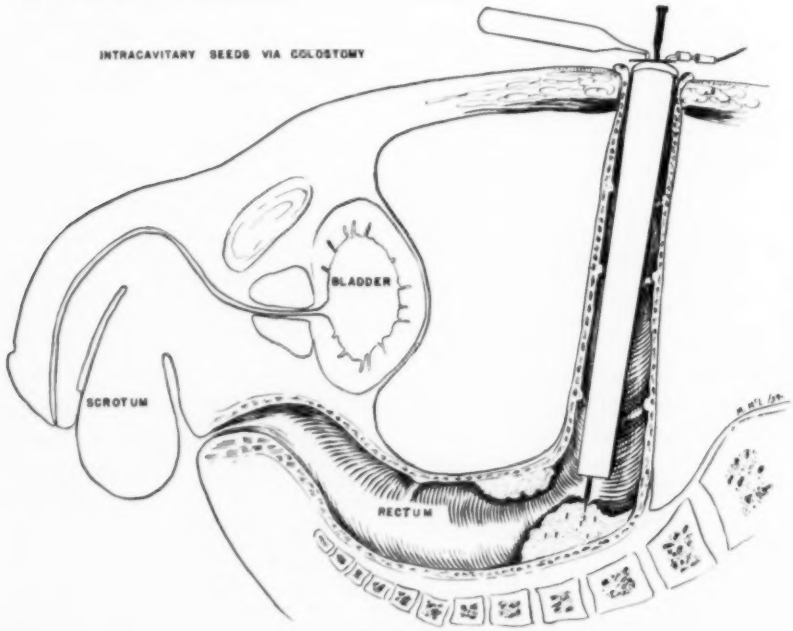

Fig. 6.

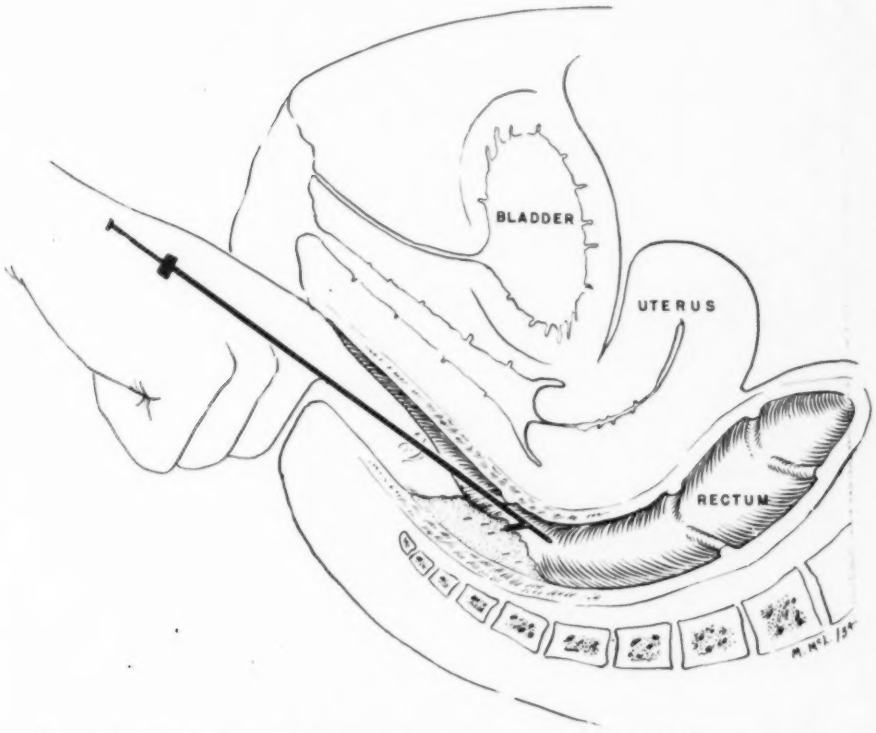

Fig. 7. Implantation of radium seeds via trocar inserted with finger as guide.

(Lockhart-Mummery believes that in the abdomen radon seeds should be used rather than needles. When intra-abdominal irradiation is employed, the doses vary from 2,500 to 6,500 mg-hr. Gordon-Watson drains the peritoneal cavity. He employs rubber sheeting with Coffey's gauze wick drains to pack off the irradiated areas until the needles are removed.)

6 operative deaths

1 reported himself as in good health 2½ years later. The remainder recurred.

It is admitted that transperitoneal irradiation is a very risky procedure and that perforation of the bowel and peritonitis have occurred. However, Gordon-Watson declares that the use of radium within the abdomen is justifiable only because of one excellent result that he obtained in which the growth was attached to the bladder and fixed to the sacrum and was successfully treated with radium needles. The patient remained well and free from symptoms nearly three years after treatment. Several similar cases have been "helped enormously." I must, however, record a case seen at the Massachusetts General Hospital in which there was apparently a large recto-sigmoidal growth fixed and involving the mucosa filling the pelvis and attached to the bladder and sacrum. Pathological report from rectum: chronic inflammation. A colostomy was done. When seen six months later, there was no evidence by rectal or abdominal examination of this large fixed mass. It must have been inflammatory.

4. Posterior barrage—9 cases.

The lines of lymphatic spread along the hemorrhoidal arteries are barraged. Thirty to 60 mg-hr. of radium is employed according to the size and extent of the growth. The wound is packed with gauze and kept moist with Carrel-Dakin's solution. The skin wound is kept temporarily closed until the radium is removed. If rectal perforation seems likely with a posterior barrage, the perineal operation is omitted and an attempt made with intrarectal seeds fortified by perirectal needles passed through the perineal skin.

Results:

2 postoperative deaths.

1 died of late secondary hemorrhage.

2 are well 2 years, and 1 year 2 months after treatment.

3 cases required hospitalization for more than three months.

(Those employing this technique feel that if a growth is adequately barraged with radium and shows little evidence of retrogression after two months, it is probably useless to repeat the irradiation.)

5. Interstitital needling (18 cases) inoperable.

1 death immediately following treatment.

6 unrelieved.

4 relieved and free from symptoms.

3 untraced.

Several perirectal abscesses. Two cases developed rectovaginal fistulae.

6. Radium for recurrent carcinoma—7 cases.
   5 unrelieved.
   2 questionably relieved.
   Comment: Recurrence was only temporarily relieved by radium.

Squamous carcinoma of anus and anal canal—8 operable, 4 inoperable.
   8 operable showed 4 good results—3 years, 3 years, 2½ years and 2 years.
   4 inoperable—1 relieved.

Complications:
1. Intrathoracic metastases—3 cases
2. 10 operative deaths
3. 1 late secondary hemorrhage
4. Several perirectal abscesses
5. 2 rectovaginal fistulae
6. 3 cases required hospitalization of 3 months or more

Conclusions: Abdominal irradiation and posterior barrage are dangerous. Intrarectal insertion of radium seeds carries less risk but produces only temporary palliation.

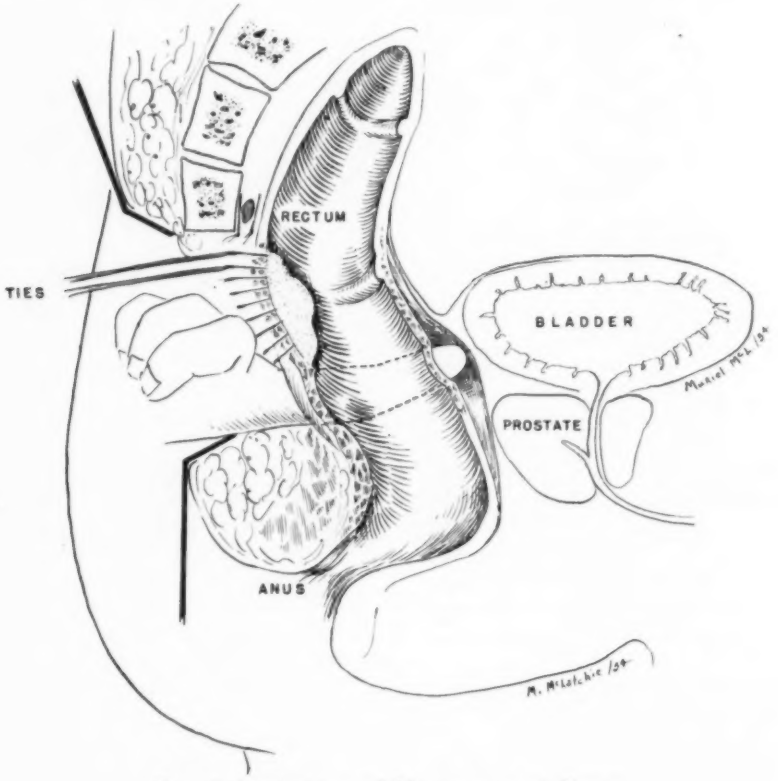

Fig. 8. Technique of Neumann and Coryn.

As regards radiosensitivity, epithelioma of the anus has been compared with epithelioma of the tongue.

These epitheliomata may extend internally or externally and one's plan of irradiation would have to vary with the type encountered.

Summary of the Cases Treated at St. Mark's Hospital

89 Cases Treated

No five-year cures.

Three-year cures—radium alone	4 cases
Adenocarcinoma of the rectum	2
Squamous carcinoma of the anus	2

Three-year cures—radium followed by posterior resection—2 cases

The disappointment felt by the group at St. Mark's Hospital regarding the irradiation of cancer of the rectum is reflected in the following figures which show the new cases admitted to the hospital for treatment:

1928— 5 cases
1929—44 cases
1930—31 cases
1931— 9 cases

There is a growing feeling that the uniform intensity delivered by the element as compared to the diminishing intensity of radon may be responsible for a greater permanency of results. There is reason to believe that the varying intensities of radon

may cause a greater irritation than the element. Seeds may leak and the strength of the individual seed may thus be inaccurately estimated.

Many feel that recurrence is more likely to follow the use of radon than the radium element. Intrarectal seeds of radom may be combined with perirectal needles of element.

out high voltage roentgen treatment is a method well worth considering. As used in the Memorial Hospital in New York, the pack contains 4 grams of radium. It is applied at from three to seven portals of entry about the pelvis. The maximum dose at each portal is 50,000 to 60,000 mg-hr. at 15 cm. from the skin. The filter at the portal is 0.35 mm. of platinum and 1.5 mm. of

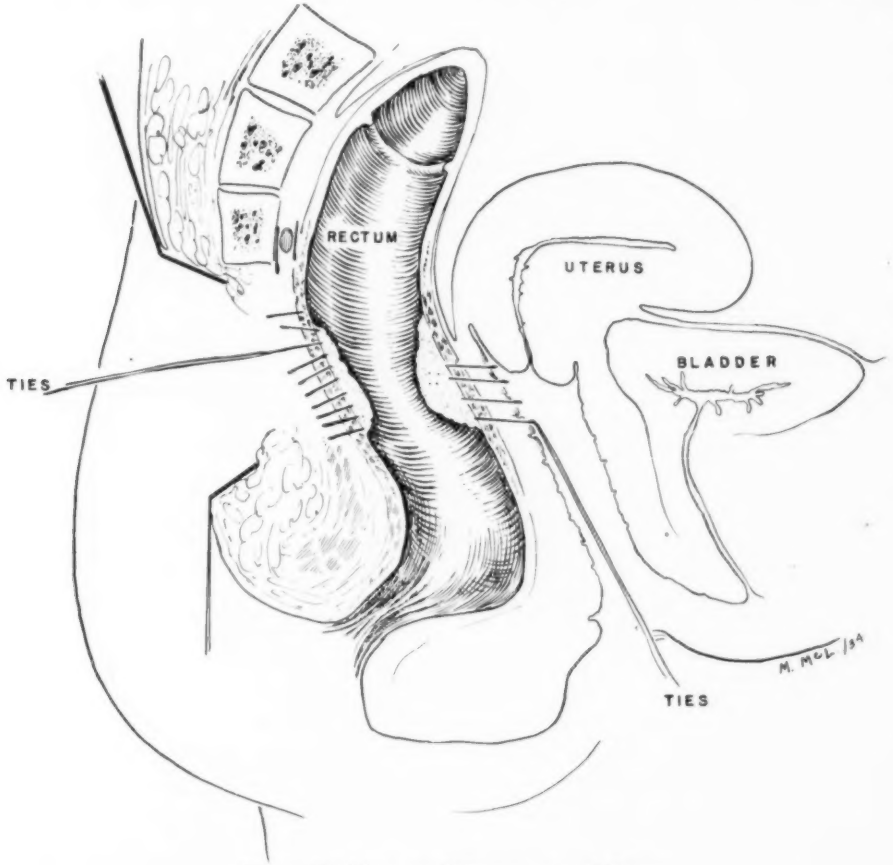

Fig. 9. Techinque of Neumann and Coryn.

Experimental work seems to indicate that the period of time required to inhibit and disintegrate a number of cells in different stages of activity is not less than about seven days. Therefore many believe that seven to ten days is the ideal duration of a treatment.

There is a good deal of question as to whether we should not experiment further, as far as cancer of the rectum goes, with minimal doses over a long period of time.

The radium pack or bomb with or without high voltage roentgen therapy may also be employed to produce 100 to 175 per cent S.E.D. (i.e., 900 r) at each portal.

Binkley follows telecurie therapy by operation after six weeks. He finds that some of his inoperable cases are made operable by irradiation. Gordon-Watson states that the best field for radium in the light of our present knowledge is the con-

version of a fixed inoperable growth into a less fixed growth. Cade reports 5 cases which were made operable after irradiation and that thereupon a perineal excision was done. Four of these, he says, are apparently cured but he does not give the postoperative time. That has not been the experience of Gabriel at St. Mark's Hospital.

Radiosensitivity. It is unfortunate that our present method of pathological grading, except in the case of young people, does not aid us very much either in a prognosis as far as the operative cases go, nor does it aid in determining radiosensitivity or resistance. The grading of a growth is not easy as different areas of the same growth when examined histologically sometimes fall in different grades. Methods change, notions of what may be expected from the irradiation of tumors may also change. It has been suggested, for example, that if current ideas of radiosensitivity were derived wholly from observations made in the days when low voltage roentgen rays represented the entire therapeutic armamentarium, the sensitive tumors would be rare and the field of radiology limited. Improved methods, while they do not alter fundamentally, present constantly a much wider applicability to the advantage of the patient with cancer. Radiosensitivity is always a relative property.

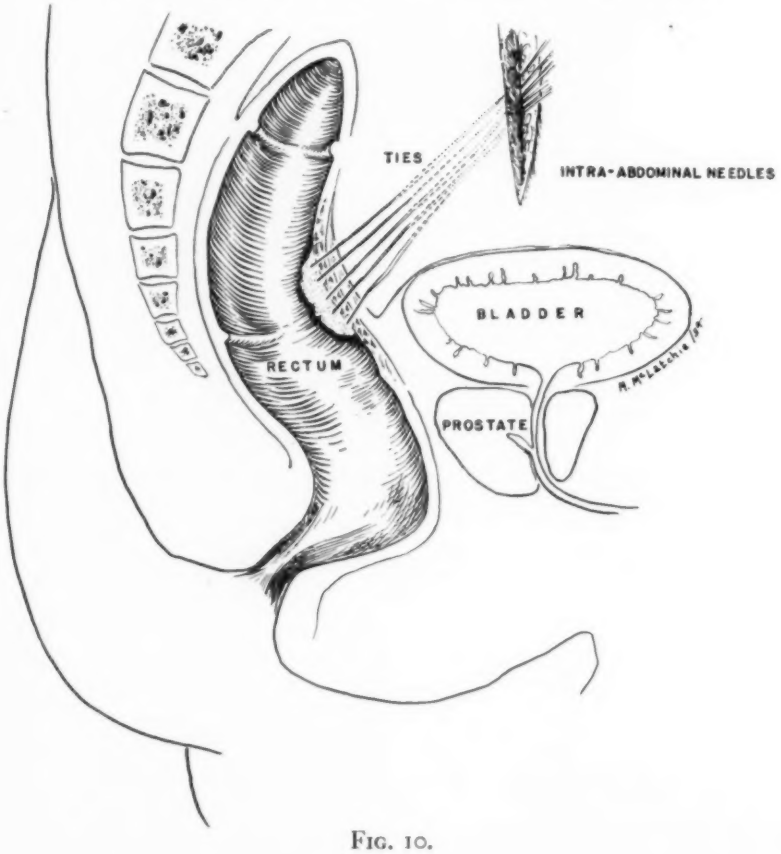

Fig. 10.

Stewart cites several factors influencing radiation: (1) anemia or cachexia; (2) infection; (3) metastasis; (4) size of tumor; (5) infarction and liquefaction. This latter may be due to the fact that fibrosis proceeds slowly and inefficiently under such conditions. Tumor cells lying in the midst of degenerative or secretory mucin may be resistant.

Not all of the tumors graded as highly malignant are radiosensitive, and a tumor graded as low malignancy occasionally

shows a surprisingly good response to irradiation. There is an urgent need for research on methods of sensitization of radioresistant tumors, such as are the majority of cancers of the rectum. We need an index of sensitivity and a corresponding dose index.

Maisin and his associates state that they can produce radiosensitization of cancer by two intravenous injections a week of 2 c.c. of a colloidal solution of uranium thorium hydroxide, giving a total of not more than five injections. This is followed by Coutard's method of roentgen irradiation. Following this, needles containing 4 mg. of radium with 0.3 mm. platinum filter are inserted via the rectal lumen. They are left in forty-eight to seventy-two hours. They occasionally supplement this treatment with a rubber sound containing three tubes of 20 mg. of radium filtered with 2 mm. of platinum. This is left in place from twelve to twenty-four hours. These authors show comparative tables:

First group of 88 patients treated with radium:

6 per cent living after 6 months
3 per cent after 1 year
1 per cent after 3 years

Second group of 100 patients with radium plus roentgen therapy:

40 per cent living after 6 months
4 per cent living after 3 years
2 per cent living after 5 years

Third group of 32 patients treated with roentgen irradiation and radium plus radiosensitization:

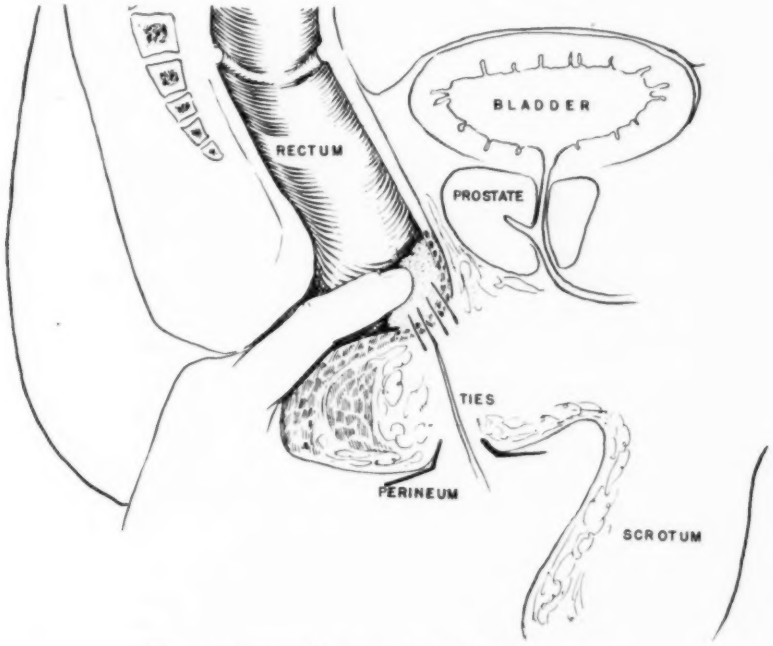

Fig. 11. Interstitial needling via skin puncture.

100 per cent healed after 3 months
57 per cent living with cancers healed after 16 to 20 months.

SUMMARY AND CONCLUSIONS

1. Adenocarcinoma of the rectum, though resistant, is not insensitive to irradiation.

2. Apparently inoperable growths can be made operable with irradiation.

3. There are a number of five year irradiation cures reported.

4. Too few are cured by this method to warrant advising anything but surgery for the operable cases.

5. Research is needed to determine criteria of correct dosage, and factors which influence the dose.

6. Methods of attack are discussed. Indications and contraindications are mentioned.

7. Opinion of most clinics is that gamma rays alone should be used and radium so applied as to produce maximum tumor destruction with minimal injury to normal tissue.

8. Radiosurgical technique of Neumann and Coryn needs further study.

9. Experience of St. Mark's Hospital in London shows that cures by this method are extemely small and that serious complications may ensue.

10. There is no definite proof supporting the statement that colostomy and perineal excision plus radium gives more cures than colostomy plus perineal excision alone.

11. Combination of high voltage roentgen therapy and the radium pack should be studied.

12. Experimental work seems to indicate that the period of time required to inhibit and disintegrate a number of cancer cells in different stages of activity is not less than seven to ten days.

13. It is probable that the uniform intensity of radium element as compared to the diminishing intensity of the radon may be responsible for a greater permanency of results.

14. There is urgent need for research in the pathological grading of tumors so that we may have an index of radiosensitivity and dosage.

15. One method of radiosensitization is discussed.

16. It has been demonstrated that by irradiation in properly selected cases (a) early growths can be destroyed; (b) a clinically inoperable growth can be rendered operable; (c) the worst and most advanced cases can be made more comfortable.

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DISCUSSION

Dr. H. H. Bowing, Rochester, Minn. I enjoyed Dr. Shedden's paper and I am happy to congratulate him. We do have a difficult time in trying to select the proper procedures in the treatment of carcinoma of the rectum. He has mentioned different techniques to be employed. The individual patient and the extent of involvement are the important factors to be considered in selecting the method to be employed. As yet we do not have a routine method or any special applicator that will give better results than another. Full cooperation on the part of the radiologist, the surgeon, and the patient is necessary to successful treatment. It does require considerable skill and great care in the treatment of this condition. I feel most certain that we have advanced our knowledge in the treatment of this disease and, as time passes, I hope physicians will be encouraged to report their cases in which treatment has been given and the results obtained.

Dr. Maurice Lenz, New York City. May I say a word about the treatment of carcinoma of the rectum with the Coutard method reported by Dr. Shedden. I have seen some prolonged palliation after a considerable amount of roentgen therapy, given principally through posterior portals on either side of the rectum. Our experience with interstitial and intercavity radium has not been as fortunate as that reported from the Memorial and other hospitals, but with roentgen therapy we have been able to obtain palliation for longer periods, especially in extensive cases, than with any other single measure we have tried.

Dr. Shedden (closing). In reply to Dr. Lenz, I might say that there is a paper written by Maisin et al[16] which discusses the question of Coutard method of high voltage roentgen-ray treatment of cancer of the rectum and has a very interesting series of figures relating to it.

THE PROTECTION OF THE RADIOLOGIST*

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PHILADELPHIA, PENNSYLVANIA

"Lives of great men all remind us
We can make our lives sublime
And departing, leave behind us
Footprints on the sands of time."
—LONGFELLOW.

WHETHER we choose footprints or stars to guide us depends upon whether we are walking in light or in darkness. We have had a number of great leaders whose footsteps we now follow and to whom we are much indebted. These men serve as inspiring and guiding lights to lead us onward into new fields and greater endeavor. We meet tonight to honor one of these men, Dr. Henry H. Janeway. As his colleagues, associates, and members of this Society whom we have learned to honor and follow, I must mention the late Professor William Duane, who made some of Janeway's work possible and who has done some of the most fundamental work in the physics of radiology; the late Dr. Robert Abbe, who was one of the pioneers of the world in the clinical application of radium; the late Dr. John G. Clark, who probably did more than anyone in this country to establish the value and obtain the recognition of radium as a means of treating gynecological conditions; the late Dr. Burton J. Lee, who has established particularly the value of radium and the roentgen ray in the treatment of malignant disease of the breast; the present Dr. Howard Kelly who has not only proved the value of radium in gynecology but also has demonstrated its value in the treatment of many forms or locations of malignant disease, and Dr. James Ewing, who is still our leader in the study of the radiosensitivity of the various types of malignant disease and who is our great critic and counsellor. These men, whom I have mentioned, more than we, appreciated and stimulated Dr. Henry H. Janeway while he was doing his pioneer work.

Lest we forget the basic principles of character which have made Janeway great, I quote from Ewing, who has said, "The qualities which led to his success were scientific imagination, indomitable will, untiring industry, excellent surgical training, and a strong confidence in the ultimate capacity of radiation to control cancer." He became a competent leading radiologist not by receiving an hour's instruction from a commercial salesman of radium, but by night courses in the physics of radiology during two years at Columbia University and by constant clinical evaluation of the biological effects. If all physicians or surgeons who attempt to use radium were to master the principles of radiology in a similar manner, more progress would be made. When we realize that all this work was accomplished in the midst of an extensive practice and while suffering from a neoplastic disease during sixteen years, and from which he died, we can appreciate the effort required to follow such a leader.

Among other accomplishments he was a leader in the protection of the radiologist.

Protection[1] is the first law of nature.[2] It is quite proper therefore in this nonscientific session that we should consider this basic problem. We need (1) protection from the effects of the radium; (2) protection against loss of radium; (3) protection from the damaging effects of radium upon patients, and (4) protection of the radiologist as a specialist.

[1] Pfahler, G. E. Protection in radiology. Am. J. Roentgenol., 1922, *9*, 803–808. This article gives other details upon the general subject as recommended by me at that time.

[2] Kaye, G. W. C., Bell, G. E., and Binks, W. Protection of radium workers from gamma radiation. *Brit. J. Radiol.*, Jan., 1935, *8*, 6–26.

* Janeway Memorial Lecture delivered before the American Radium Society at the Twentieth Annual Meeting, Atlantic City, N. J., June 10–11, 1935.

The need of personal protection is indicated by the fact that radiologists are affected by various pathological conditions caused by radiations, chief of which probably is radiologist's cancer. In 1934, Colwell and Russ found that more than 200 radiologists have died of malignant disease secondary to radiation effects. It is a fact that most of these have been roentgen-ray workers, and that very few have developed cancer following radium exposures. One reason is that as radium came into more general use more knowledge of protection was available. The roentgen-ray workers are more likely to suffer from malignant disease secondary to skin damage especially due to roentgenoscopy. Radium workers, on the other hand, tend to suffer from anemia, while the roentgen-ray workers are less liable to this effect. It seems that the gamma rays from radium have a greater tendency to produce anemia than the roentgen rays. Radium workers do damage the ends of their fingers.

(1) *Personal protection from the effects of radium* depends primarily upon distance. The greater the distance, the greater the safety. In this respect distance in millimeters is as important with regard to radium as is distance in centimeters in relation to roentgen rays. Therefore, *radium specimens should never be handled by the fingers*. The specimens should always be handled with instruments. The longer the instruments, the safer, but, of course, the more difficult. Rubber gloves give a little but insufficient protection to the skin of the hands from the secondary radiation effects coming from the radium containers.

Even the older radiologists who have already damaged the skin of their fingers and hands can be helped and need protection. They should avoid so far as possible every bit of exposure. By personal experience I find that the oil glands in the skin of my hands have been nearly all destroyed. Such skin will not stand frequent washing, especially with soap. Therefore, I urge and practice the wearing of gloves at all work and all play. White cotton gloves should be worn for all dry work, and rubber gloves for all other examinations or manipulations. Leather gloves should be worn while playing golf. For cleansing the hands, I seem to find "tersus" (oliphatic ester—pH 6.8) a "soapless soap" agreeable to my sensitive skin but even this takes out the oil and leaves the skin dry. Following any cleansing process it is absolutely essential, every time, to rub into the skin some bland oil. When nothing else is available, butter may be used. I have found toilet lanolin, "Desetin Roentgensalbe," and some cold creams agreeable, such as "nivae cream." At present I am using:

Cod liver oil	oz. 2
Castor oil	oz. 2
Nivae oil	oz. 2
Oil of pine needles	m. 60

This is rubbed into the skin very well at least twice daily. For those who have developed marked atrophy, fissures, or keratoses, I would advise electrodesiccation or excision and skin grafting but never the application of radium.

When dealing with the larger quantities of radium, lead must be our main protection. To obtain absolute protection by means of lead 6 inches or 15 centimeters in thickness must be used. Lead is much cheaper than the expenses of recovery from the constitutional effects from radium exposure. It has been found practical for the technician who prepares the specimens of radium or applicators to work with a table which is protected on five sides by 6 cm. of lead encased in 1 cm. of wood, providing the technician will only expose the hands at the end of long forceps and for the shortest possible time. The technician should not remain in the room where the radium is stored in larger quantities for a longer time than is necessary. In other words, radium should not be stored in the office where the radiologist or his assistants spend most of their time. An ordinary steel safe is not sufficient protection. The device previously described by me[3] which provides

[3] Pfahler, G. E. A safety device for the care of radium contained in needles and capsules. Am. J. Roentgenol. & Rad. Therapy, 1924, *12*, 580–581.

a special place for each specimen of radium with a handle to the tray protected everywhere by 5 cm. of lead and thus stored in the steel safe will add to protection.

Signals of danger to the general body may be recognized and, therefore protection provided, by having a thorough blood examination at least twice a year. Anemia, lymphocytosis, and leukopenia are danger signals.

It is self-evident that there is more damage from large quantities of radium than from a small quantity, but most of us have done the damage to our fingers with small quantities of radium on the assumption that the slight exposure would do no harm. Radium should be carried or pushed in a carriage from place to place in lead containers at as much distance as possible from the body. All that I have said regarding personal protection is known by every competent radiologist, but is ignored or forgotten by many. Rules are especially ignored by those who do not devote their entire time to radiology.

(2) *Protection against the loss of radium* is a very important matter, as is indicated by the high insurance rates in the past. High premiums that we pay become the penalty for the carelessness of our colleagues. Radium for safety should be kept in the 5 cm. lead mold in a burglar proof safe and kept in a room which is only open to those who have control of the radium and should be kept locked at all other times. Radium is rarely stolen, but is usually lost through soneone's carelessness.

The radium container should have a compartment for each specimen or group of specimens so that they can be counted or checked quickly and easily by two persons who see that those specimens not in the container are in proper use upon some patient or patients, and such fact should be noted in a book which should be dated and signed by the two inspectors at the end of each day. The dressings used in connection with radium each day should be kept in a separate paper bag which is dated and placed in a suitable can. The can should be kept for two weeks. It is only when some combination of circumstances leads someone to break a link in this chain of protection that radium can be lost in this manner, as I shall show you by an example.

On Armistice Day, November 11, 1931, while conducting a committee meeting on cancer control at the Philadelphia County Medical Building at 5.30 P.M., as my office was about to be closed, I received a telephone call that there was missing 100 milligrams of radium. No explanation of this loss could be given. The office force was requested to remain until I arrived. I then learned that the particular radium lost consisted of two 50 milligram capsules which had not even been used on that day but had been used on the previous day in the treatment of cancer of the mouth. I found that the special lead applicator which I had built to treat that particular case was also missing.

I was assured in the most positive terms by the nurses that the radium had been placed in the safe and that the radium had been inspected by two nurses, and all was found in place during the previous evening, but since the lead applicator was missing, I was doubtful as to the accuracy of these statements. It was and is our custom to preserve the dressings and the rubber removed from the applicators in a special paper bag for each day, and to preserve all of the paper bags in the container reserved for that purpose for a period of two weeks. When we searched for the day's paper bag, we found it missing. Likewise, I was unable to find the can containing the two weeks' supply.

A new maid had come to the office force during that particular week, and when she took the can to the elevator, she met the man who hauls away the trash from the building. Therefore, instead of this particular can of material being taken to the basement and preserved during two weeks, it landed on the waste truck. At about this time, the ownership of the building had changed hands, and with some difficulty, through the new owner, we learned the name of the trucker who had been removing the trash. We found he lived about forty miles away in New Jersey. We also found that his telephone had been disconnected. Through the district country police, we however learned where he lived, and after driving forty miles, first to the police station, we were taken to the home of this man who had already gone to

bed. It was then approximately 9 o'clock. His door bell was out of order, but fortunately, the policeman's "black jack" was sufficient to arouse the man from his slumbers.

I told him that we had lost a valuable instrument which I was anxious to use on the following day. He fortunately remembered the particular load of trash that he had removed from our building, and remembered having dumped it about a half mile from his house. We then tramped through the fields to this local dump, but as we approached the dump, he recalled that he had not taken that particular load to the New Jersey dump near his home but to the League Island City dump, an area of about ten acres. Without any further services on the part of the policeman, the trucker kindly guided us in his car to the Philadelphia dump, but being Armistice Day, when we reached Camden, we found a parade in session which delayed us for a considerable time in reaching the ferry. Finally, at 11 o'clock, we reached the dump and, with flashlights, we searched until the truckman was able to recognize some of the material that was on that particular load removed from our building.

Every possible attempt was made to reach the insurance company immediately upon learning of the loss of the radium, but being Armistice Day, and a legal holiday, it was impossible to make any connection with the insurance company. I did succeed, however, in reaching Mr. J. L. Weatherwax, who has served us all so well as physicist. One of my assistants remained at the dump where, of course, we found many smells and many rats, and early the following morning, Mr. Weatherwax, with his magical electroscope, searching over the general area where this load of trash was dumped, succeeded in getting an ionization effect on his instrument, and by tracing closer and closer, and after digging, at one point for a distance of 2 feet in depth, the radium was recovered, still in the applicator, and still in the rubber dressings.

It then transpired that the young nurse who was supposed to have put the radium in the safe and who was ready to swear that she had put it in the safe had hastily put the radium and its applicator in a basin and hurried off to do some shopping, for she was to be married two weeks later. The radium which looked to the new maid like ordinary waste material was of course discarded, and thereby furnished the material for this story.

Radium may be lost by a patient or within a patient. The patient should not be allowed to leave the room, and if it is applied in cavities he should not be allowed to go to the toilet. A strong string applied to each specimen will add to the protection. For this purpose I have found the linen thread (Barbour's Irish flax carpet thread) bought in skeins to be the strongest and most satisfactory. Black thread for applicators within the mouth is better than white. One must be careful not to cut the thread with forceps in applying the radium within cavities. Finally, protection against loss should be obtained from a reliable insurance company.

(3) *Protection against the damaging effects of radium upon patients.* The radiologist can protect himself against this hazard by protecting the patient, by mastering the most modern technique, by taking due account of the extent of the disease, the radiation effect necessary to be produced, and the preparation of the radium necessary to produce these effects; as to quantity, filtration, distribution, distance, the proper direction and the intervals between the treatments. These considerations make the problem quite complicated, and I believe there is no more difficult form of treatment in medical practice. It is often necessary in the treatment of malignant disease to produce some damage to the normal tissues. We should aim to keep such tissue damage within the limits of the possibility of recovery, or within the possibility of surgical repair. Criticism and complaint can often be avoided by explaining, before witnesses, in advance, to someone in the family who is responsible, the possibility or likelihood of such damage.

Finally, and especially in these days of financial distress, and especially if the patient does not get well, or if the patient has not paid the bill, one may be sued for damages when there may be no foundation whatever. It must not be forgotten that you may be sued by a charity patient either in your private office or when you have treated them at a hospital. For protection

against such damage suits, an insurance contract should be carried.

(4) *The protection of the radiologist, or of radiology as a specialty.* Radiology as a specialty is, I think, the most comprehensive of all specialties in medicine, and therefore is the most difficult to master; and yet many seem to think the only essential requirement is the possession of an x-ray machine or the possession of a small or large quantity of radium. The possession of such instruments go just as far to make a radiologist as the possession of surgical instruments go to make a surgeon. Such instruments are essential but money can buy them. The great essentials that make up a competent radiologist or a surgeon cannot be bought. They require such great characteristics as Janeway and our other leaders have had: scientific imagination, indomitable will, untiring industry, patient study, and a belief in what you are doing.

To be a complete radiologist one should have in addition to the usual medical training some special training in anatomy, pathology, the physics and mathematics of radiation, and a clinical knowledge not only of general medicine but of the fundamentals of each of the specialties and the special technical skill necessary for diagnosis and treatment of the diseases belonging to each of the other specialities. It can be readily seen therefore that it is a life long study.

Because of the tremendous difficulty in the mastery of all of these subjects, specialists within the specialty of radiology have developed and they have advanced our knowledge to a considerable degree. As a matter of fact, the American Board of Radiology recognizes and certifies in three main branches: roentgen diagnosis, roentgen therapy, and radium therapy. It is with the branch of radium therapy that we are especially concerned. Because of the fact that radium is used in the other specialties there is a considerable danger in hospitals of the radiologist becoming a mere custodian of the radium, and a technician in the preparation of the specimens for use by the other specialists. If the radiologist under such circumstances is well informed, he will observe in many instances that the other specialist has ignored or is unfamiliar with the most fundamental principles of radiology. Under such circumstances good results are not obtained and radium therapy is condemned. It is certainly possible for any of the other specialists to learn the fundamentals of radiology, as has been proved by Surgeon Janeway who took night courses during two years for this purpose.

In the same manner it is entirely possible for the radiologist to learn the necessary surgical technique for the applications of radium to the various parts of the body. When, however, the surgeon has not learned the essential principles of radiology, and radiological technique, or the radiologist has not learned the essential surgical technique, it is self-evident that the two should combine their skill and knowledge, each acting as consultant and thus protect radiology and at the same time do the greatest good to the patient.

These principles should govern whether dealing with a patient in a private office or in the hospital.

In a similar manner, the specialty of radiology can be protected if each radiologist by his study, skill and special knowledge can prove continually a superior ability in dealing with radium by producing superior results. In all instances he should be able to hold his position on a plane with that of every other specialist, and, toward this end, he should aim to obtain similar financial arrangements with the hospital as obtains with the surgeon and other members of the hospital staff. If they are all on a salary he can afford to be on a salary. If the hospital collects the surgeon's fee on a commission, or some other basis, the radiologist can do likewise. If the surgeon or his patient pays a fee for the use of the surgical equipment and the operating room personnel, then the radiologist can do likewise. In all instances, it must be remembered that if the radiologist is not finan-

cially supported and is not provided a decent living wage commensurate with the extraordinary effort necessary to become a good radiologist, then fewer of the better class of men will enter this specialty, radiology will suffer, and ultimately the patients or the public will fail to get the high class service otherwise possible. We, including the general public, must always remember that we must pay for what we get, and we ultimately get just about what we pay for. Even protection costs both money and effort and those who expect protection without expending money and effort will be disappointed. Let us keep in mind continually the tremendous energy, industry and earnestness of our leader Janeway.

"Difficulty is a nurse of greatness—a harsh nurse, who rocks her foster children roughly, but rocks them into strength and athletic proportions. The mind, grappling with great aims and wrestling with mighty impediments grows by a certain necessity to the stature of greatness."—Bryant.

PROGRESS IN THE DESIGN OF SHOCK PROOF ROENTGEN TUBES FOR THERAPY AND INDUSTRIAL ROENTGENOGRAPHY*

By M. J. GROSS, M.S.
Tube Department, General Electric X-Ray Corporation
CHICAGO, ILLINOIS

IN MANY therapy installations danger of electric shock from exposed high tension parts has been minimized by placing the roentgen tube in a large metal drum, under a couch, or on the opposite side of a wall or floor. When properly carried out, these schemes have been reasonably effective in giving both roentgen-ray and electrical protection. In all of them, however, protection has been obtained at the expense of flexibility of movement of the roentgen-ray source, and treatment technique is consequently limited. Effort has been directed in the last several years towards obtaining both protection and flexibility through the design of a powerful shock proof source of roentgen rays compact enough and flexible enough to be moved in any position with respect to a patient, at any distance, and with any size field. This has opened up interesting speculation as to new possibilities of treatment.

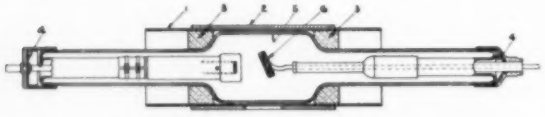

FIG. 1. Essential elements of a high power therapy roentgen tube for use with shock proof container. 1. High dielectric strength insulating cylinder between tube and grounded lead. 2. 5 mm. inch thick lead at ground potential. 3. High percentage lead oxide impregnated insulating rings. 4. Lead lined bases. 5. Thick glass vacuum envelope of roentgen tube. 6. Coils through which cooling oil can be circulated within three-sixteenths inch of focal spot.

Design of such a unit was attacked on the basis of obtaining an energy capacity, kilovoltage rating, and reliability of performance at least equivalent to that of the water-cooled Coolidge therapy tube. Oil and solid insulations were selected as logically the best dielectrics with which to surround the tube if compactness combined with reliability under varying atmospheric conditions was to be obtained. The following developments were involved:

1. A roentgen tube of reasonable dimensions suitable for operation in close proximity to ground potential.
2. A forced oil-cooling system to remove heat from the anode of the tube, rather than the water-cooling system that had been in use for years.
3. A high voltage cable, flexible and, above all, reliable.
4. A shock proof container for the roentgen tube, compact, oil-filled, of reasonable weight, and shape convenient for movement to any position with respect to a patient.

1. *Tube Development.* Roentgen tube design presents problems that bear on many different fields of knowledge and that in most cases can be effectively solved only after considerable experimental trial and error. The tube shown in Figure 1 is the end-result of over 50 experimental tubes involving tests totaling more than 125,000 milliampere-hours of operation. The relative physical dimensions of the various portions of the tube are of importance in controlling the high velocity electrons and in dissipating the resultant heat generated, in distributing the voltage stresses, and in obtaining roentgen-ray protection.

A novel, but simple, scheme was found for bringing ground potential close to the center of the tube, namely, introduction of a thin solid insulating material between the tube envelope and ground. This method imposed few limitations on the tube design, making possible a simple, easily degassed

* Read at the Thirty-fifth Annual Meeting, American Roentgen Ray Society, Pittsburgh, Pa., Sept. 25–28, 1934.

tube and at the same time allowing ground potential to be brought very close to the glass envelope. It was first used in connection with a roentgen-ray protected series of diagnostic tubes (XP tubes). Alternate methods of bringing ground potential to the center of the tube depend upon special tube designs, such as the double glass wall tube made by the Siemens Co. and the metal center tube made by the Philips Metalix Co. The essential characteristic of the solid insulation method is that the insulation have at all points sufficient dielectric strength to prevent the voltage charge on the tube envelope from discharging to ground. Obviously, this necessitates passing the roentgen rays through the solid insulation, because any opening in it would provide an air path that would destroy its insulating qualities at that point. Laminated paper impregnated with phenolic resin has proved to be the best insulation because it combines high dielectric strength with low roentgen-ray absorption and fair heat resistance.

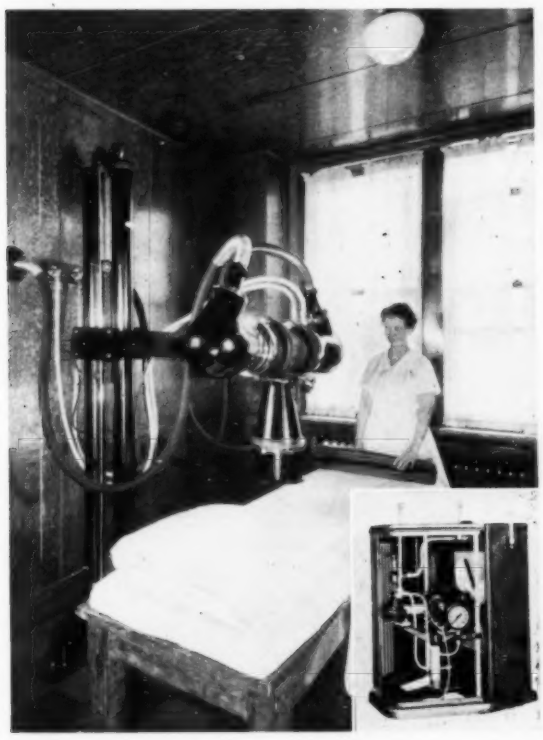

Fig. 2. Hospital installation of 220 kv.p., 20 ma., shock proof therapy roentgen unit. Insert shows oil circulating and cooling unit.

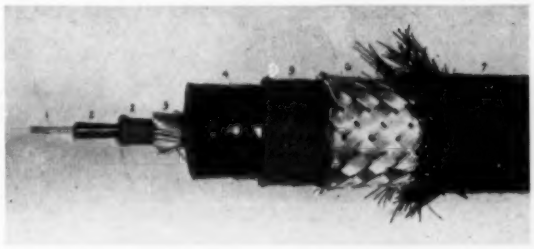

Fig. 3. Flexible high voltage cable for roentgen therapy application. 1. Central conductor. 2. Insulation between conductors. 3. Second conductor. 4. Cambric oil impregnated insulation. 5. Weatherproof insulation. 6. Grounded metal sheath. 7. Cotton and silk covering.

Evidence that nothing in performance has been sacrificed in making the shock proof tube of Figure 1 is the fact that this same tube without its solid insulation and grounded lead protection has completely replaced the older bulb type water-cooled Coolidge therapy tube for use in drums, under couches or in lead glass bowls. It has a higher kilovoltage rating combined with a longer life expectancy.

2. *Oil-Cooling System.* Oil has been introduced as a cooling medium for therapy tubes even where protection is not involved. It makes a simpler system than where water is involved because the pumping and cooling equipment can be located at ground potential and the oil pumped through a short insulating tube to the roentgen tube anode voltage. Obviously, this is doubly so where shock proofing is involved and the same oil that is circulated through the anode can be allowed to flow around the tube and insulate it from the shock proof container (see Figs. 2 and 4).

Both the cooling properties of oil and its dielectric properties are too well known in the many applications to machinery and electrical equipment design to require any discussion as to the fundamental soundness of this system. A tube problem was encountered, however, because of the permeability of hot oil, in certain cases through even vacuum tight metal, and because of its poorer heat conductivity as compared

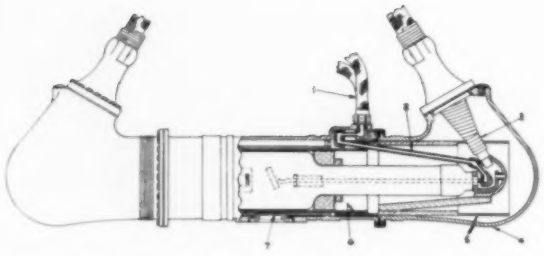

Fig. 4. Assembly of roentgen therapy tube and shock proof container. 1. Oil inlet and outlet hoses. 2. Insulating tubing for carrying oil from ground to anode potential. 3. High voltage cable terminal. 4. Grounded oil filled aluminum casing. 5. Solid insulation cylindrical barrier. 6. More solid insulation. 7. Roentgen-ray outlet window assembly.

to water. Before entirely satisfactory results were obtained a special oil had to be developed for the application.

3. *High Voltage Cable.* High voltage cables for power transmission have been developed by the electrical industry to a high state of reliability but such cables are not flexible to the degree necessary for this application. The insulation of such cable is almost invariably made up of oil impregnated paper or a cambric cloth. Because we had available this industrial experience of cable design it was natural to try to make use of those materials and methods of manufacture that have proved so satisfactory for high voltage power cable work. Flexibility was obtained by reducing the conductor cross section which in a power cable might be as large as several square inches to approximately 10 per cent of this, by eliminating the usual heavy lead covering and by designing for D.C. voltage (Fig. 3). It is an interesting fact that a good cable will stand two or three times as high a rectified voltage as it will alternating voltage. The resulting cable combines sufficient flexibility with a safety factor and durability which is more than satisfactory.

4. *Shock Proof Container.* The configuration shown in Figure 4 gives sufficient clearances in oil for operation up to 300 kv.p. Inasmuch as the tube is rated to only 220 kv.p., this means a large safety factor. Little would be gained, however, in weight or size by smaller clearances. The design shown requires only about 4 gallons of oil. Effective use is made of solid insulation. Oil as a dielectric, of course, eliminates the influence of altitude, barometric pressure, and humidity—atmospheric conditions which appreciably influence the breakdown of air as a dielectric. The problem of designing for universal use in widely different climates is therefore simplified as the container is equally as usable in hot, humid weather as cold, dry weather and in high altitudes as at sea level.

No attempt has been made to give complete roentgen-ray protection as this would have little meaning with a powerful beam of high voltage roentgen rays producing scattering wherever they hit on the patient or surrounding tables, walls, or floors. A 5 mm. band of lead is placed around the tube, which in conjunction with the massive tube-electrode construction and heavily lead impregnated bakelite rings around each end of the tube intercepts all direct radiation from the target of the tube except that in the useful cone of roentgen rays (Fig. 1). This insures protection adequate for the patient, specifi-

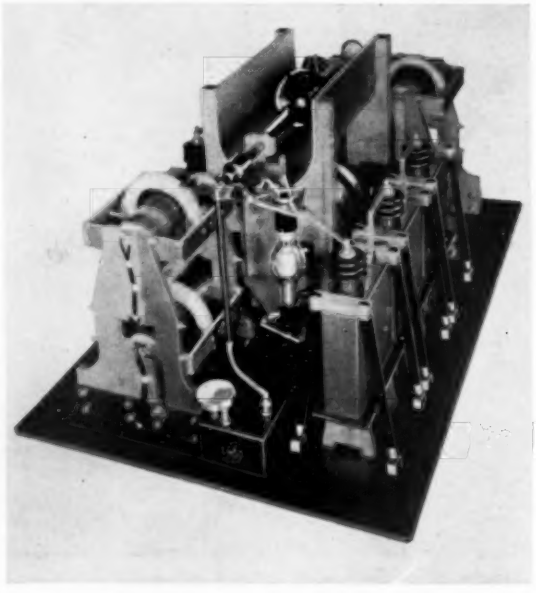

Fig. 5. Internal structure of 300 kv.p. shock proof unit for industrial roentgenography.

cally such that at equal distances from the container the scattered radiation intensity from the tube is less than 1 per cent of the beam radiation intensity filtered through 1.0 mm. of copper. Additional protection must, of course, be provided for the operator.

INDUSTRIAL ROENTGENOGRAPHY

Industrial roentgenography involving metals up to 4 inches in thickness has proved its value in many industries. This is especially true in the roentgenographing of heavy welds in boilers, penstocks, tanks, and other places where strength and reliability are of first importance. Voltages up to 300 kv.p. are required for some of this work. The need for shock proof equipment is equally as great as in the medical field because of the variety of parts that must be roentgenographed and the fact that in many cases they are so large and heavy that the roentgen equipment must be brought to them rather than the reverse. The work is usually done, not in a laboratory, but in a crowded factory or outdoors on location.

The therapeutic shock proof tube that has been described is suitable with certain modifications for metal roentgenography up to several inches of steel in thickness. It is adaptable to many conditions in that it can be used indoors or outdoors, being independent of atmospheric conditions, and that it can be moved into small openings or around a complicated structure.

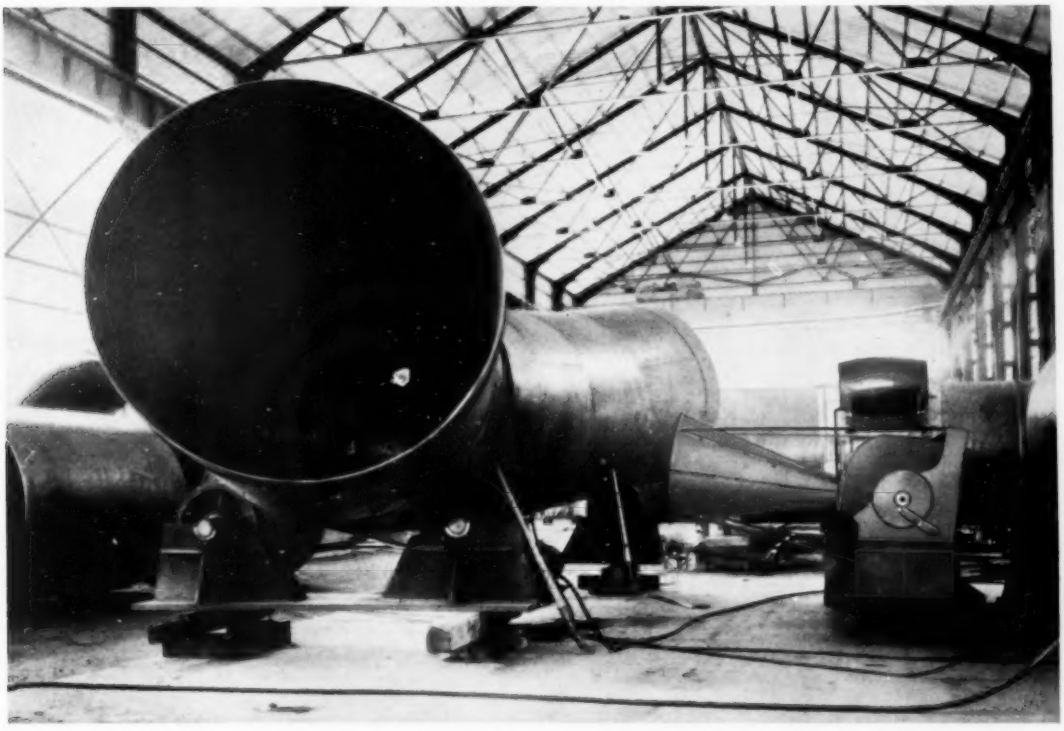

Fig. 6. Shock proof unit of Figure 5 on location at Boulder Dam for roentgen examination of penstock welding.

Another type of shock proof unit has been developed for high voltage roentgenography in which all of the high voltage generating equipment and the roentgen tube are brought together in one oil filled container (Figs. 5 and 6). This, of course, makes a relatively heavy unit which, however, is entirely self-contained and can be readily handled in an industrial plant where a crane or other equipment for mov-

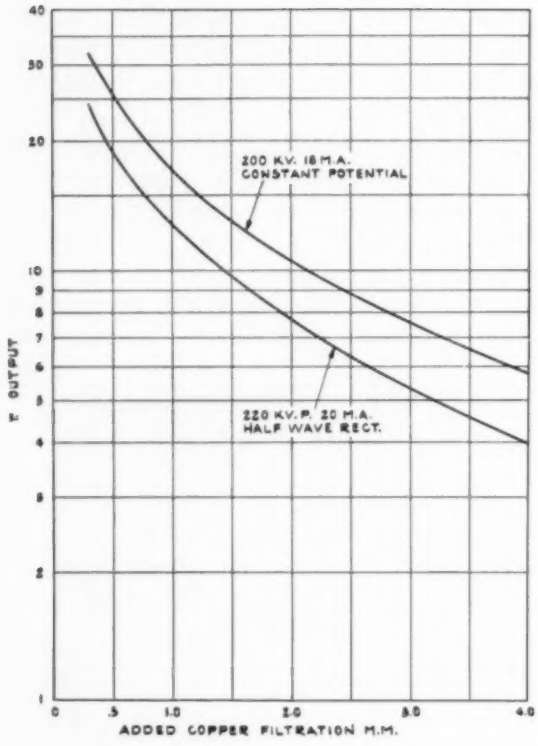

Fig. 7. Roentgen (r) output at maximum ratings of shock proof unit shown in Figures 1 and 4; 80 cm. distance, no back-scattering, inherent filtration: 5 mm. glass, 6 mm. bakelite, 1.5. mm. oil, total approximately equivalent to 0.25 mm. of copper.

ing heavy parts is available. Such units have been built for roentgenography up to 300 kv.p., and the design is applicable for even higher voltage; 300 kv.p. allows examination of 3.5 inch thick steel welds on a practical production basis (Fig. 8).

CONCLUSIONS

Design of the shock proof equipments described was motivated by a need in both the therapeutic and high voltage industrial roentgenographic fields for protection combined with flexibility of movement of the roentgen-ray source. Summary of the developments involved shows that oil as a dielectric and as a cooling medium has played an important part in solving the problems of voltage and power dissipation. Design of the roentgen-ray tube proper has been influenced by a desire for simplicity and reliability. Nothing has been done inside of the vacuum container that in any possible way could be done equally as well outside and around the tube. This same consideration of reliability has also dominated the cable development. Two radically different arrangements of equipment have been described for obtaining a powerful high voltage source of roentgen rays, each of which in its respective field adequately meets the need of protection combined with flexibility.

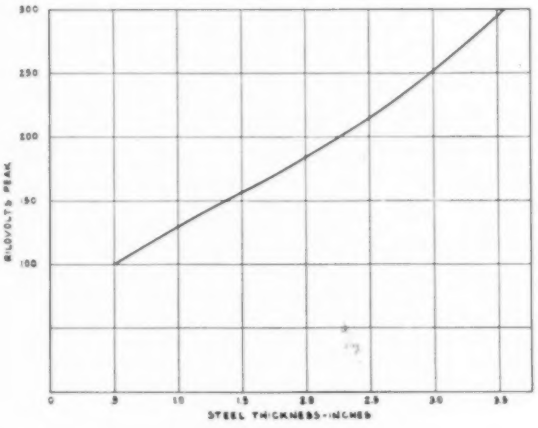

Fig. 8. Relationship between kilovoltage and thickness of steel that can be roentgenographed in a five minute exposure, at a 36 inch distance, with the shock proof equipment shown in Figure 5.

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FACTORS INFLUENCING THE QUANTITATIVE MEASUREMENT OF THE ROENTGEN-RAY ABSORPTION OF TOOTH SLABS*

I. RADIATION FACTORS

By HAROLD C. HODGE,† PH.D., GRANT VAN HUYSEN,‡ D.D.S., *and* STAFFORD L. WARREN, M.D.

ROCHESTER, NEW YORK

IN ARRIVING at a satisfactory precision method for studying tooth tissues by their roentgen-ray absorption, it was found necessary to carry out a somewhat complicated series of experiments designed to test the conditions under which the method proposed to function. It was proposed: (1) to establish the limits within which the experimental conditions (such as tube voltage, film-target distance, type of film, etc.) might be varied without influencing the relative absorption by the tooth tissue and (2) to establish the amount of variation produced in the absorption values for the tooth tissues by a given variation in the experimental conditions. The results, briefly stated, of the series of experiments permitted us to conclude that many of the experimental conditions may be varied within wide limits without influencing the relative absorption values, while other conditions must be carefully duplicated in order to obtain the reproducibility necessary for precise measurements. In order to obtain a complete and fundamental study of the conditions which we surveyed, a precise study in the sense which the research deserves as a part of the science of physics, it would be necessary to elaborate our work at least a hundred fold. For three reasons we did not see fit to make this extended research: (1) four of us worked full time for over a year to carry out the limited experimentation we are reporting, thus it would require many years for the completion of a precise study; (2) many of the conditions varied by us were theoretically predicted not to have any influence on the relative absorption value (although experimental evidence to confirm the theory has not been published), and when we found no influence we accepted the result without exhaustive and meticulous repetitions; (3) a great deal, if not all, of the work involving similar *photographic conditions* has been done in an exhaustive fashion by experts in photographic research. Most of these data have been filed in the archives of industrial plants but have not been made available through publication. Others attempting to study this problem afresh would perforce be confronted by the necessity of repeating our scientifically inconclusive but sufficiently exact experiments. We are therefore publishing our results with the hope that they may stimulate others to use this method of research in this and related fields. We would also suggest that some of the fundamental problems be studied by expert and interested workers with the carefulness and exhaustiveness which these fields deserve.

This paper is the first in a series of papers presenting the data collected in prospecting the variations produced by changing the many factors in the technique which are listed in outline form in a previous paper.[1] In brief, if these factors could be made constant, they would allow a just comparison of results. However, so many of the materials and measurements are subject to small and at present, unavoidable

† Rockefeller Senior Fellow in Dentistry.
‡ Rockefeller Fellow in Dentistry.

[1] Warren, S. L., et al. A quantitative method for studying the roentgen-ray absorption of tooth slabs. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *31*, 663–672.

* From the Departments of Biochemistry and Pharmacology, Pathology and Medicine (Radiology) of the University of Rochester School of Medicine and Dentistry, Rochester, N. Y.

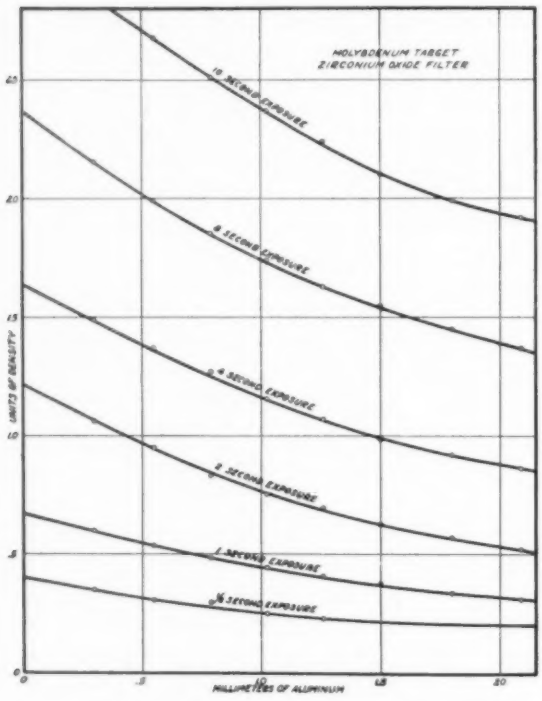

Fig. 1. In 6 films taken with increasing exposure times the D.Rs. in the various steps of the penetrometer are plotted against the proper thicknesses of aluminum. Note that the curves are practically parallel at equal densities.

variations, that the influence of each factor should be investigated sufficiently to indicate the relative changes produced. The previous paper should be referred to for the basic method and terminology. It should be pointed out that the tooth slab is used for this study (1) because it has constant or measurable physical dimensions and properties and (2) because it is being used by other investigators in this laboratory for chemical, hardness, histological and other studies which can be correlated with the absorption studies. Any other material with the proper criteria could be subjected to similar investigations.

Herewith are presented a series of experiments whose purpose is to determine the effect, if any, on the absorption values for tooth tissue of the type of radiation used, i.e., when monochromatic, ordinary heterogeneous or "white," grenz, and secondary radiations are used to measure the absorption.

Monochromatic Radiation

In order to test whether monochromatic radiation gives I.Vs.* of the same magnitude as those obtained with "white" radiation such as is used routinely for roentgenography, a series of exposures were made using a molybdenum target tube with a zirconium oxide filter.

In Table 1 are recorded the D.Rs.* in the various steps of the penetrometer in 6 films taken with a molybdenum target tube having

* Abbreviations employed:
I.Vs.—Interpolated value, i.e., the relative absorption of the tissue in terms of mm. Al equivalent (1).
D.Rs.—Densitometer reading, from Capstaff-Purdy densitometer.
D-T curve—Density thickness curve, the absorption curve in which density units are plotted against thicknesses in mm. of the Al penetrometer (1).

Table I

Molybdenum target tube, 50 kv., 30 ma., 30 inches, zirconium oxide filter

Film	8311			8312			8313			8314			8315			8316		
Exposure	½ second			1 second			2 seconds			4 seconds			8 seconds			16 seconds		
Densitometer Readings																		
Penetrometer																		
Step 1—0.34	0.35	0.36		0.59	0.61	0.61	1.05	1.06	1.08	1.47	1.52	1.48	2.17	2.14	2.14	2.8+	2.8+	2.8+
2—0.30	0.31	0.31		0.55	0.54	0.52	0.94	0.95	0.94	1.36	1.37	1.38	2.00	1.99	1.98	2.68	2.68	2.67
3—0.28	0.30	0.28		0.48	0.49	0.48	0.82	0.83	0.85	1.28	1.28	1.26	1.85	1.86	1.85	2.51	2.51	2.52
4—0.26	0.24	0.25		0.43	0.46	0.44	0.75	0.75	0.76	1.14	1.16	1.16	1.75	1.75	1.72	2.37	2.36	2.37
5—0.25	0.24	0.22		0.40	0.41	0.41	0.68	0.71	0.70	1.07	1.08	1.06	1.64	1.65	1.62	2.24	2.24	2.23
6—0.22	0.22	0.22		0.39	0.36	0.38	0.63	0.61	0.63	0.98	0.98	0.99	1.55	1.55	1.54	2.09	2.12	2.10
7—0.20	0.20	0.20		0.34	0.34	0.32	0.57	0.56	0.58	0.91	0.92	0.93	1.46	1.44	1.46	2.00	1.99	1.99
8—0.22	0.22	0.22		0.30	0.32	0.30	0.51	0.52	0.52	0.85	0.87	0.85	1.37	1.37	1.37	1.94	1.92	1.91
Enamel —0.22				0.38			0.68			1.00			1.53			2.06		
Dentine —0.30				0.52			0.88			1.25			1.88			2.50		
Interpolated Values																		
Enamel —1.20				1.44			1.30			1.47			1.52			1.63		
Dentine —0.67				0.66			0.72			0.82			0.74			0.80		

a zirconium oxide filter at 50 kv. (sphere gap), 30 inch target film distance, 30 ma. tube current and ½, 1, 2, 4, 8, and 16 second exposures. The D–T curves* (see Fig. 1) are similar and placed with fairly regular increase of ordinate in order of increasing length of exposure. The D-T curve for the shortest exposure, ½ second, is nearly horizontal, for succeeding longer exposures the D-T curves increase in slope with increase in length of exposure, that for the longest exposure, 16 seconds, being steepest. It is interesting to note that for equal D.Rs. the curves are practically parallel. The D-T curves are distributed over nearly the whole range of exposures, that for ½ second being in the region of marked underexposure and that for 16 seconds in the region of overexposure. The D.Rs. *in the films* (not under the penetrometers) are 0.40, 0.74, 1.24, 1.68, 2.39 and greater than 2.8 in the order of increasing exposure times; by plotting these D.Rs. against the exposure time a typical D-E curve is obtained (Fig. 2). The I.Vs. for the enamel average are about 1.4 mm. Al; for the dentine average about 0.8 mm. Al. These data were determined early in our investigation and cannot be accepted as indicative of an increase of I.V. for either enamel or dentine with exposure time. That the I.Vs. given here are of the same magnitude as is obtained by other sources of roentgen radiation is the important deduction.

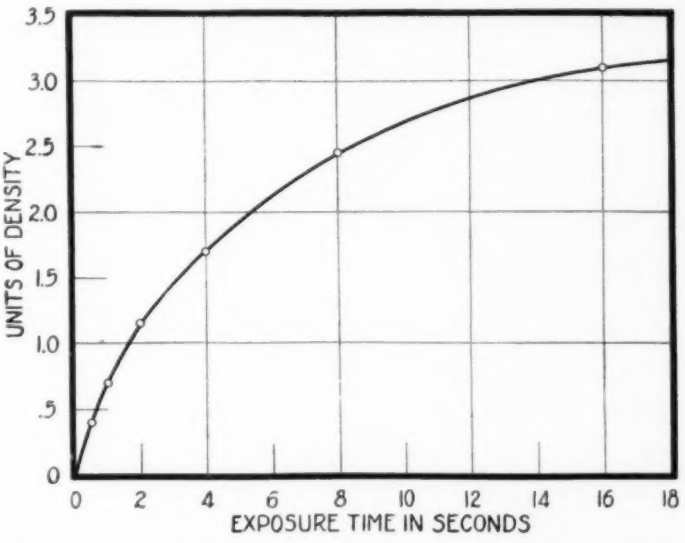

Fig. 2. A conventional density-exposure curve for film densities giving additional insight into the increments between exposures. Compare with Figure 1.

Heterogeneous or "White" Radiation

In Table II are given the D.Rs. in the various steps of the penetrometer in 6 films taken with a tungsten target tube (medium focus) at 50 kv. 30 ma., 30 inch distance, no tube stand filter, at ¼, ½, 1, 1½, 2, and 2½ seconds exposure. The D-T curves are similar in shape and slope, have a large radius of curvature and have

Table II

Tungsten target tube, 50 kv., 30 inches, 30 ma.

Film	3221		3222		3223		3224		3225		3226	
Exposure	2½ seconds		2 seconds		1½ seconds		1 second		½ second		¼ second	
Densitometer Readings												
Penetrometer	*Right*	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*	*Left*
Step 1	2.8+	2.8+	2.8+	2.8+	2.76	2.78	2.41	2.40	1.62	1.61	1.06	1.04
2	2.8+	2.8+	2.8+	2.8+	2.44	2.46	2.08	2.06	1.38	1.36	0.89	0.87
3	2.8+	2.80	2.60	2.59	2.25	2.21	1.89	1.84	1.20	1.18	0.76	0.75
4	2.63	2.55	2.35	2.37	2.03	2.01	1.69	1.65	1.08	1.04	0.68	0.66
5	2.42	2.36	2.13	2.13	1.88	1.80	1.52	1.49	0.98	0.98	0.60	0.58
6	2.27	2.22	1.98	1.99	1.70	1.70	1.39	1.36	0.90	0.88	0.57	0.54
7	2.10	2.01	1.83	1.83	1.58	1.57	1.28	1.25	0.80	0.78	0.49	0.49
8	1.99	1.97	1.73	1.73	1.49	1.48	1.17	1.13	0.74	0.69	0.47	0.44
Enamel	2.30		2.07		1.80		1.45		1.00		0.56	
Dentine	2.8+		2.54		2.20		1.83		1.18		0.75	
Film	2.8+		2.8+		2.8+		2.8+		2.07		1.37	
Interpolated Values												
Enamel		1.45		1.38		1.32		1.40		1.20		1.41
Dentine		—		0.84		0.82		0.82		0.83		0.83
Film		—		—		—		—		—		—

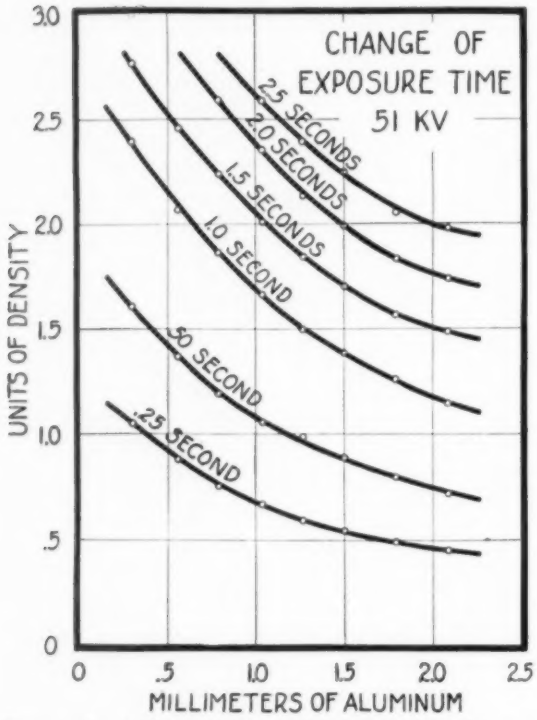

Fig. 3. In 6 films exposed with increasing times to "white" radiation at 51 kv., the D.Rs. are plotted against the proper thicknesses of aluminum.

ordinates increasing with fair regularity with increasing time of exposure (Fig. 3). The film at $\frac{1}{4}$ second exposure is markedly underexposed; the film at $2\frac{1}{2}$ seconds is exposed to a degree not measurable by the Capstaff-Purdy densitometer. The I.Vs. for the enamel average about 1.35 mm. Al, for the dentine they average about 0.83 mm. Al. The exact I.Vs. are not important but the fact that values are of the same magnitude as those obtained using other sources of roentgen radiation is important.

GRENZ RADIATION

In order to compare the I.Vs. obtained at the higher kilovoltages (20–80 kv.) with I.Vs. for enamel and for dentine obtained with the so-called grenz-ray tube at the lower kilovoltages,* a series of exposures are made at 10–12 kv., 3 ma., $\frac{1}{2}$ and $\frac{1}{4}$ seconds with the specimen close to the window of the grenz-ray tube. In order to use short exposure time, the tooth slab used is ground plano-parallel to a thickness of 0.15 mm. and a penetrometer is made by clipping together a number of strips of commercial aluminum foil of unknown composition (Fig. 4, a grenz roentgenogram).

* For those interested in the possibilities of grenz-ray study, a preliminary investigation of the I. V. obtained using roentgen rays (30 kv.) with 0.8 mm. thick slab and using grenz rays (12 kv.) with the same slab ground to a thickness of 0.15 mm. has been published by Van Huysen, Hale and Hodge (*Dental Cosmos*, 1935, 77, 146). A comparative study of the absorption by densitometric and ionization methods is included. From the data presented, the authors conclude that there is no regular difference between I. Vs. obtained from thick sections using roentgen rays and I. Vs. from thin sections using grenz rays. The I. Vs. were of completely comparable magnitude whether obtained densitometrically or by ionization measurements.

Table III

Thickness of Al Penetrometer mm.	Densitometer Readings
Step 1—0.08	2.8+
2—0.15	2.35
3—0.23	1.81
4—0.30	1.41
5—0.38	1.10
6—0.45	0.89
7—0.52	0.67
8—0.60	0.52
	Interpolated Values (mm. Al)
Enamel—1.11	0.37
Dentine—1.83	0.23

Table IV

SCATTERED RADIATION, TUBE VOLTAGE 40 KV., 30 MA., 720 SECONDS

Film.....1291	1292
Exposure	
Densitometer Readings	
Penetrometer	
Step 1—2.36	1.99
2—1.87	1.57
3—1.58	1.35
4—1.37	1.15
5—1.21	1.01
6—0.97	0.88
7—0.93	0.75
8—0.86	0.73
Enamel—1.16	0.92
Dentine—1.55	1.31
Interpolated Values	
Enamel—1.27	1.40
Dentine—0.83	0.83

The Al penetrometer ranges from 0.08 mm. Al (Step 1) to 0.60 mm. Al (Step 8). The D.Rs. (Table III) under the various steps of the penetrometer range in Step 1 to Step 8 from greater than 2.8 to 0.52. The D-T curve is typical (see

Fig. 5), smooth, and similar to D-T curves obtained with lower kilovoltages using a Coolidge tube. The D.R. in the enamel is 1.11, in the dentine is 1.83; the I.V. for enamel is 0.37, for the dentine is 0.23 mm. Al. It is interesting to compare these I.Vs. with those for the specimens of 0.8 mm. thickness. Since the I.V. for dentine is of great constancy and approximately equal to the thickness of dentine, a proportion is set up as follows: what would be the I.V. for enamel if the I.V. for the dentine is set equal to 0.8 mm. Al, keeping the same ratio between the I.Vs. for enamel and dentine as is found with grenz rays?

$$\frac{\text{I.V. En}}{\text{I.V. Dent}} = \frac{\text{I.V. En Calc.}}{0.8}$$

(Grenz rays)

$$\frac{0.37}{0.23} = \frac{\text{I.V. En Calc.}}{0.8}$$

$$\text{I.V. En (Calc.)} = 1.29 \text{ mm. Al}$$

Thus the I.V. for enamel on a proportional basis is 1.29 mm. Al if the I.V. for the dentine is 0.8 mm. Al. By comparison with the values obtained at other kilovoltages it is seen that there is no difference in the relative magnitudes

Fig. 4. A grenz roentgenogram of the Al-foil penetrometer and a 0.15 mm. thick tooth slab. The dark line on the penetrometer is the shadow of a wire staple such as is used to fasten papers.

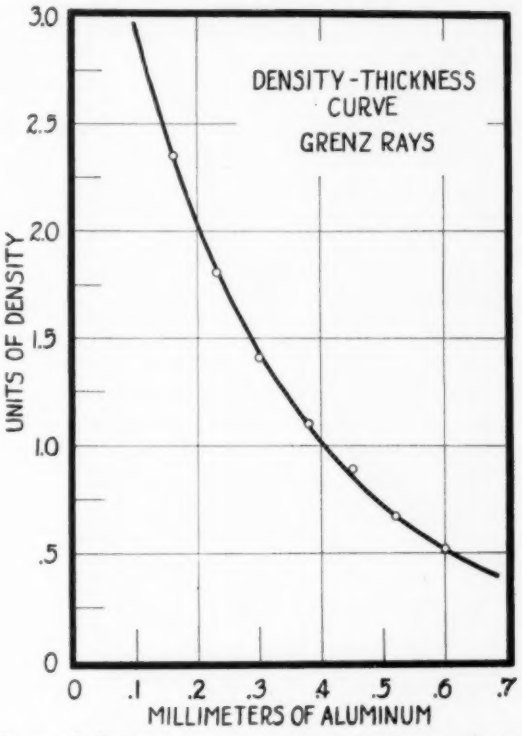

Fig. 5. D.Rs. in the grenz roentgenogram are plotted against the proper thicknesses of Al-foil. Note the similarity to D-T curves at higher kilovoltages.

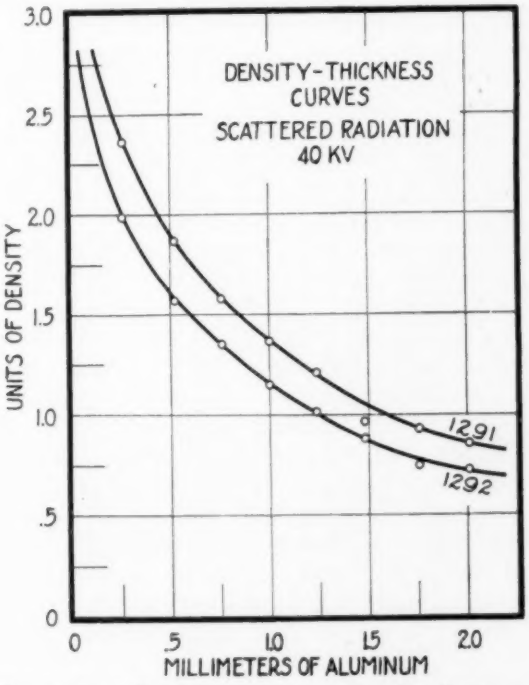

Fig. 6. In 2 films exposed to scattered radiation at 40 kv., the D.Rs. are plotted against the proper thicknesses of aluminum.

of the I.Vs. whether obtained at 20–80 kv. or at 10–12 kv. (See also discussion under "Voltage Change" in a later paper.)

SCATTERED RADIATION

In an effort to find the effect of different sorts of radiation on the I.V. for enamel and for dentine, it is proposed to test the effect of scattered radiation. The experimental work was carried out by W. Bale of this laboratory. A cube of paraffin about 1 cm. on each edge is set up in the roentgen-ray beam. Approximately 7 cm. from the paraffin, which serves as the secondary radiator, the film (in these exposures, large dental film) is fixed with the tooth slab and penetrometer in place. The films are taken at 40 kv., 30 ma. and 720 sec. exposure. In Table IV are given the D.Rs. in 2 films. The D-T curves (see Fig. 6) are parallel, no different from the D-T curves obtained at 40 kv. using the direct beam. (See discussion under "Voltage Change" in later paper.) The I.Vs. for enamel are 1.27 and 1.40 mm. Al, for the dentine 0.83 mm. Al, in films 1291 and 1292, respectively; values are comparable in all respects to those obtained using other sources of radiation.

SUMMARY

The relative magnitudes of the interpolated values (I.Vs.) for enamel and for dentine are found to be not significantly different for monochromatic, heterogeneous or white, grenz and secondary roentgen radiation.

The I.V. for enamel is about 1.4 mm. Al at 50 kv., for dentine about 0.8 mm. Al.

Vol. 34, No. 4

FACTORS INFLUENCING THE QUANTITATIVE MEASUREMENT OF THE ROENTGEN-RAY ABSORPTION OF TOOTH SLABS*

II. FILTER FACTORS

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A. ALUMINUM TUBE STAND FILTER

SINCE the character of the tube stand filters and cassettes commonly used as standard roentgenographic equipment has a great influence upon the results obtained, it seems important to review in some detail the method used to evaluate and eliminate such variables as may be present. Only sufficient data are presented to illustrate the magnitude of these errors. As pointed out in a previous paper these data do not represent an exhaustive study from the photometric standpoint because of the relatively small number of observations made upon any particular variable. In the main, they are sufficient for our purpose, which was to improve the accuracy of the densitometric study of the tooth slab.

After approximately four years of intermittent study and research for a precision method of studying roentgenograms, it was believed that the greatest difficulties had been surmounted and that the outline of such a method was in hand. Consequently it was with the keenest disappointment when a trial of the method made on a tooth slab whose dimensions, specific gravity, chemical composition and other properties were constant and measurable, revealed that 6 films taken under what was considered to be exactly reproduced conditions and developed simultaneously gave I.Vs. (interpolated values) for the enamel and the dentine which varied among themselves by 35 per cent. The removal of the tube stand filter (a sheet of aluminum approximately 1 mm. thick) permitted the precision to be improved by approximately 20 per cent, consequently the process of elimination by which the tube stand filter was shown to be responsible for that much variation is of interest.

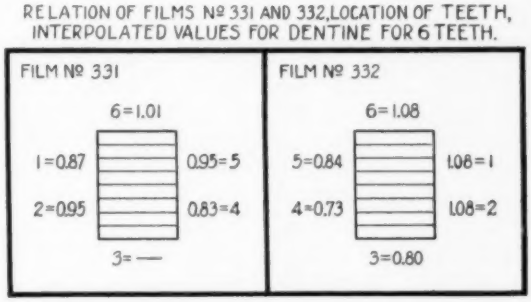

FIG. 7. Each 5″×7″ film is exposed in halves. Note that teeth No. 3 and 6 are in the same relative position in each half, while teeth No. 1 and 2 are interchanged with No. 4 and 5 in the right hand half.

Six films were made with the tube stand filter in place, at 51 kv., 30 inch distance, 30 ma. and 1 second exposure. Six tooth slabs were distributed around the penetrometer to obtain confirmatory evidence. Two exposures were made on each 5″×7″ film as has been described in the method paper.[1] The D.Rs. (density readings) in the various steps of the penetrometer are given in Table v. When plotted, the D-T (density-thickness) curves (not shown) are logarithmic, closely bunched and similar. The films were exposed in halves so that films no. 311, 321, and 331 were on the left halves of the three 5″×7″ films, while films no. 312, 322 and 332 were on the right halves of the same three 5″×7″ films (Fig. 7). It is seen (Table v) that

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‡ Rockefeller Fellow in Dentistry.

[1] Warren, S. L., Bishop, F. W., Hodge, H. C., and Van Huysen, G. A quantitative method for studying the roentgen-ray absorption of tooth slabs. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *31*, 663–672.

* From the Departments of Biochemistry and Pharmacology, Pathology and Medicine (Radiology) of the University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.

TABLE V

AL TUBE STAND FILTER IN PLACE, 51 KV., 30 INCHES, 30 MA., 1 SECOND

Film / Exposure / Densitometer Readings	Film 311	Film 312	Film 321	Film 322	Film 331	Film 332
Penetrometer						
Step 1	1.36–1.40–1.39	1.37–1.39–1.37	1.41–1.39–1.39	1.32–1.36–1.36	1.40–1.42–1.40	1.34–1.34–1.32
2	1.30–1.32–1.34	1.24–1.28–1.27	1.32–1.30–1.30	1.27–1.27–1.26	1.34–1.32–1.30	1.23–1.22–1.22
3	1.22–1.22–1.21	1.20–1.20–1.19	1.23–1.24–1.22	1.18–1.18–1.19	1.22–1.23–1.22	1.17–1.18–1.16
4	1.16–1.18–1.17	1.12–1.12–1.14	1.16–1.12–1.10	1.14–1.10–1.12	1.16–1.14–1.15	1.08–1.08–1.06
5	1.08–1.09–1.09	1.08–1.08–1.06	1.08–1.09–1.10	1.03–1.05–1.04	1.08–1.07–1.06	1.02–0.99–1.01
6	1.03–1.07–1.05	0.99–0.99–0.98	1.02–1.02–1.00	0.98–0.99–0.96	1.03–1.01–1.00	0.98–0.92–0.90
7	0.93–0.97–0.98	0.96–0.94–0.92	0.94–0.95–0.93	0.93–0.92–0.91	0.97–0.94–0.97	0.89–0.90–0.89
8	0.90–0.89–0.89	0.89–0.88–0.84	0.89–0.90–0.89	0.86–0.83–0.85	0.88–0.89–0.88	0.84–0.83–0.80
Enamel	1.04	0.97	1.02	0.96	1.02	0.90
Dentine	1.22	1.16	1.24	1.16	1.20	1.06
Interpolated Values						
Enamel	1.46	1.64	1.48	1.55	1.48	1.64
Dentine	0.84	0.94	0.73	0.87	0.87	1.08

the ranges for the D.Rs. in the step tablets in films No. 311, 321 and 331 are approximately 1.40 to 0.90 while the ranges for the films No. 312, 322, and 332 are approximately 1.35 to 0.85. The significance of this regular variation will be discussed later. The D.Rs. for Tooth No 1 (the tooth slab used throughout the establishing of the reproducibility of the method) in the enamel are 1.04, 0.97, 1.02, 0.96, 1.02, and 0.90, in the dentine are 1.22. 1.16, 1.24, 1.16, 1.20, and 1.06 for films No, 311, 312, 321, 322, 331 and 332, respectively. The I.Vs. for the enamel of Tooth No. 1 are 1.46, 1.64, 1.48, 1.55, 1.48 and 1.64 mm. Al, in the dentine are 0.84, 0.94, 0.73, 0.87, 0.87 and 1.08 mm. Al for films No. 311, 312, 321, 322, 331 and 332, respectively. The I.Vs. vary by about 10 per cent in the enamel and by about 35 per cent in the dentine.

To investigate the cause of this degree of variation, D.Rs. were made in the enamel and in the dentine of the tooth slabs from teeth No.

TABLE VI

DENSITOMETER READINGS AND INTERPOLATED VALUES IN MILLIMETERS OF ALUMINUM FOR ENAMEL AND DENTINE OF 6 TEETH

Tooth	Tissue	Film 311		Film 312		Film 321		Film 322		Film 331		Film 332	
	Enamel Dentine	D.R.	I.V.	D.R.	I.V.	D.R.	I.V.	D.R.	I.V.	D.R.	I.V.	D.R.	I.V.
1	E	1.04	1.46	0.97	1.64	1.02	1.48	0.96	1.55	1.02	1.48	0.90	1.64
	D	1.22	0.84	1.16	0.94	1.24	0.73	1.16	0.87	1.20	0.87	1.06	1.08
2	E	0.98	1.69	0.97	1.64	1.01	1.52	0.93	1.67	1.03	1.44	0.89	1.69
	D	1.19	0.94	1.12	1.13	1.20	0.82	1.11	1.02	1.18	0.95	1.06	1.08
3	E	0.98	1.69	0.99	1.56	0.97	1.71	0.96	1.54	0.98	1.64	0.97	1.38
	D	1.17	1.00	1.16	0.94	1.22	1.20	1.15	0.89			1.16	0.80
4	E	0.97	1.73	0.99	1.56	0.98	1.66	0.98	1.46	0.94	1.60	0.96	1.41
	D	1.15	1.07	1.18	0.88	1.18	0.89	1.16	0.86	1.22	0.83	1.18	0.73
5	E	0.98	1.69	1.00	1.52	1.00	1.58	1.01	1.35	1.00	1.55	0.95	1.45
	D	1.17	1.00	1.18	0.88	1.16	0.99	1.17	0.83	1.18	0.95	1.14	0.84
6	E	0.96	1.78	0.87	2.12	0.98	1.66	0.97	1.50	0.96	1.72	0.90	1.64
	D	1.14	1.10	1.07	1.24	1.14	1.04	1.15	0.89	1.16	1.01	1.06	1.08

Table VII

DENTINE ONLY

Tooth No.	1	2	3	4	5	6
I.V. Max. (mm. Al)	1.08	1.08	1.20	1.07	1.00	1.24
I.V. Min. (mm. Al)	0.73	0.82	0.80	0.73	0.83	0.89
Diff. (Max.-Min.)	0.35	0.26	0.40	0.34	0.17	0.35

2, 3, 4, 5, and 6 and recorded in Table VI along with the I.Vs. in mm. Al for enamel and for dentine in each tooth. A description of the table is not important; however, the maximum and minimum I.V. for dentine in mm. Al (see Table VII) will give a good idea of the variation shown by the teeth named.

It is apparent that all the teeth show differences of approximately the same order.

If the variation is common to the I.Vs. for all the teeth it might be hypothetically ascribed to a difference in the intensity of radiation from the tube, the difference occurring so as to give more energy or radiation of a lesser wavelength on one part of the film than on another. A comparison of the ranges of the D.Rs. in the penetrometer on the right halves as against the left halves of the 5″×7″ films (see above) gave a bit of evidence which in some measure confirmed this hypothesis. The D.Rs. in Step 1 for the left half films (No. 311, 321, 331) are about 1.40, for the right half films (No. 372, 322, 332) are about 1.35 which would indicate more radiation on the left half than on the right and a subsequent increase in density of the film. However, to attribute the magnitude of variation found in the I.Vs. to this difference seemed impossible.

Nevertheless, further credit was given the hypothesis by the study of the relation between the position of the tooth on the film and the I.V. found. The teeth were arranged as is shown in Figure 7 around the penetrometer. It is noted that tooth 6 is opposite tooth 3 and that teeth 1 and 2 are opposite teeth 4 and 5. If the radiation over the film is geometrically asymmetrical as assumed, the I.Vs. for teeth 1 and 2 should vary in some fashion opposed to the variation in the I.Vs. for teeth No. 4 and 5. Although for simplicity and clarity, the variation in only teeth 2 and 4 are plotted in Figure 8, they represent fairly well the irregular manner in which all the I.Vs. varied. The I.Vs. for the dentine only are shown. These in tooth No. 2 are low in films No. 311, 321, and 331 and high in films No. 312, 322 and 332, evidence which would detract credence from the asymmetrical radiation hypothesis, until it is observed that teeth No. 1 and 2 were interchanged with No. 4 and 5 in certain films, 1 and 2 being on the left hand side of the penetrometer in films No. 311, 321, and 331 and on the right hand side in films No. 312, 322 and 332 (Fig. 7). However, in tooth No. 4, the values are high for film No. 311, medium for No. 312, 321, 322 and 331 and low for No. 332 which certainly does not strengthen the case.

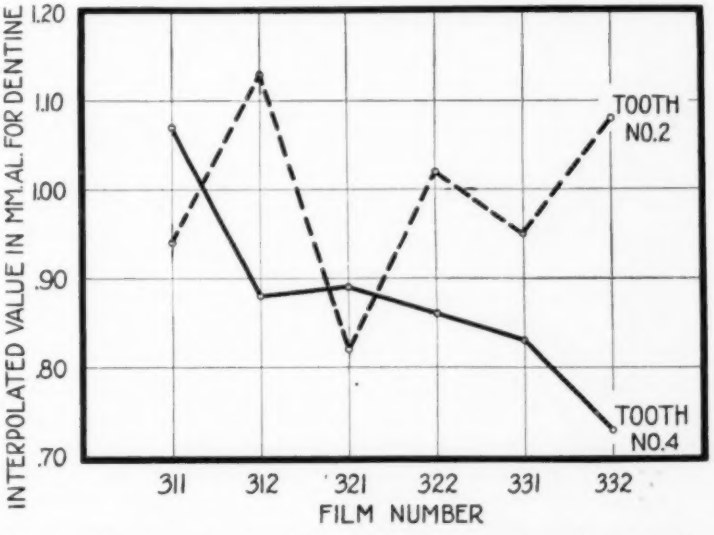

Fig. 8. The I.Vs. for teeth No. 2 and 4 plotted against the film number. Note the tendency for variations in opposite directions, i.e., high values for tooth No. 2 accompanying low values for tooth No. 4.

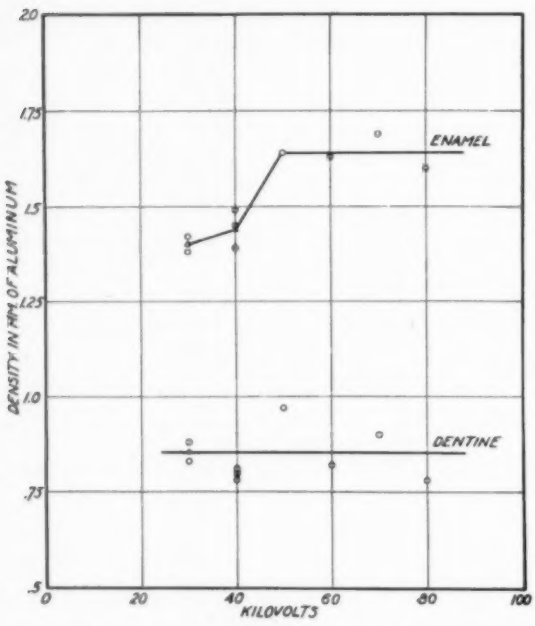

Fig. 9. Early work seemed to show a constancy of I.V. for dentine with kv. change, but a critical voltage for I.V. for enamel between 40 and 50 kv.

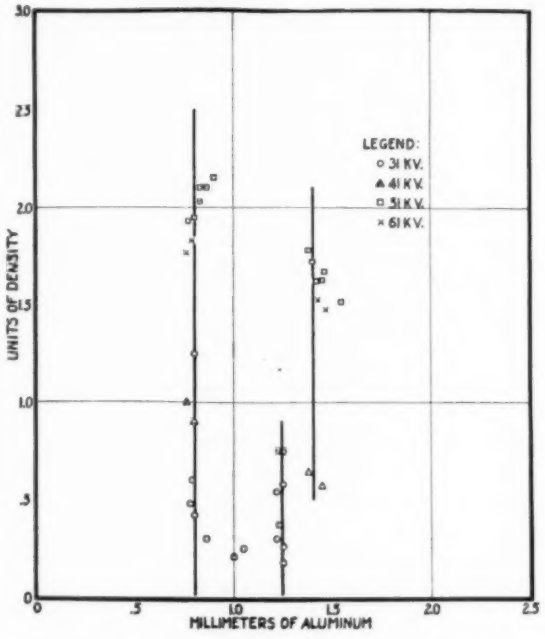

Fig. 10. D.R. plotted against I.V. for dentine (vertical line at left) and for enamel (two vertical lines at right) at various kilovoltages. Further investigation with improved precision confirmed the constancy of I.V. for dentine although kv. and D.R. in dentine vary between wide limits. The I.Vs. for enamel are about 1.4 mm. Al for 40, 50 and 60 kv. but are about 1.2 mm. Al at 30 kv., independent of the magnitude of D.R. in enamel.

Since teeth No. 2 and 4 are on opposite sides of the penetrometer, it is of interest to observe that in the same film high values in tooth No. 2 are associated with low values in tooth No. 4, and vice versa. Although the magnitude of difference is widely variable, nevertheless some connection between the I.V. in mm. Al and the place of the tooth on the film seems undeniable. That the tube might be responsible for such a large variation as found was not held possible, Consequently a search was instituted for some factor or some part of the equip-

Table VIII

CARDBOARD, 32 KV., 15 INCHES, 30 MA., NO FILTER, 2 SECONDS

Film	Film 41		Film 51	
Densitometer Readings				
Penetrometer	*Left*	*Right*	*Left*	*Right*
Step 1	2.65–2.57–2.54	2.50–2.43–2.42	2.48–2.49–2.47	2.44–2.45–2.40
2	1.94–1.93–1.91	1.85–1.80–1.78	1.85–1.85–1.85	1.84–1.82–1.81
3	1.44–1.44–1.41	1.41–1.37–1.36	1.41–1.41–1.41	1.41–1.37–1.35
4	1.11–1.08–1.09	1.05–1.03–1.05	1.06–1.06–1.06	1.09–1.05–1.05
5	0.84–0.81–0.85	0.80–0.79–0.83	0.80–0.83–0.83	0.81–0.82–0.81
6	0.66–0.60–0.64	0.64–0.62–0.62	0.61–0.61–0.61	0.63–0.63–0.64
7	0.51–0.49–0.51	0.50–0.48–0.51	0.50–0.50–0.50	0.49–0.49–0.49
8	0.45–0.45–0.45	0.45–0.45–0.45	0.42–0.45–0.46	0.44–0.45–0.47
Enamel	0.85		0.84	
Dentine	1.42		1.43	
Interpolated Values				
Enamel	1.23		1.24	
Dentine	0.78		0.76	

TABLE IX

I CARDBOARD, 32 KV., 30 INCHES, 30 MA., NO FILTER, 10 SECONDS

Film	Film 71		Film 72		Film 73		Film 74		Film 75		Film 76	
Densitometer Readings												
Penetrometer	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*
Step 1	2.47–2.45	2.46–2.43	2.47–2.47	2.49–2.48	2.46–2.48	2.42–2.43	2.44–2.43	2.47–2.47	2.54–2.51	2.46–2.46	2.43–2.44	2.42–2.41
2	1.90–1.89	1.90–1.87	1.89–1.89	1.90–1.88			1.92–1.89	1.89–1.90	1.92–1.94	1.92–1.90	1.89–1.87	1.88–1.86
3	1.49–1.49	1.47–1.45	1.49–1.47	1.47–1.47	1.50–1.50	1.48–1.46	1.45–1.45	1.45–1.45	1.48–1.50	1.45–1.45	1.43–1.45	1.42–1.45
4	1.18–1.21	1.18–1.16	1.15–1.13	1.16–1.18	1.20–1.20	1.14–1.17	1.16–1.17	1.15–1.17	1.19–1.21	1.15–1.17	1.14–1.17	1.15–1.15
5	0.91–0.92	0.91–0.89	0.89–0.89	0.91–0.94	0.92–0.92	0.89–0.92	0.92–0.93	0.89–0.91	0.90–0.97	0.90–0.94	0.89–0.90	0.88–0.94
6	0.71–0.74	0.72–0.73	0.68–0.73	0.75–0.76	0.73–0.79	0.75–0.75	0.71–0.75	0.71–0.75	0.77–0.78	0.73–0.80	0.71–0.74	0.71–0.76
7	0.57–0.59	0.55–0.57	0.57–0.57	0.59–0.64	0.59–0.63	0.56–0.62	0.58–0.59	0.53–0.59	0.57–0.68	0.64–0.57	0.55–0.57	0.55–0.62
8	0.53–0.53	0.51–0.53	0.53–0.55	0.52–0.57	0.55–0.68	0.54–0.56	0.53–0.53	0.52–0.54	0.56–0.58	0.52–0.58	0.52–0.55	0.54–0.57
Enamel —0.99			0.94		1.01		0.94		0.97		0.94	
Dentine —1.49			1.45		1.48		1.50		1.49		1.45	
Interpolated Values												
Enamel —1.19			1.23		1.18		1.23		1.22		1.22	
Dentine —0.78			0.80		0.80		0.77		0.79		0.79	

ment capable of causing a variation estimated roughly at 0.3 mm. Al (Table VII). The filter placed in the tube stand was suspected. It is a sheet of Aluminum approximately 1 mm. thick and presumably uniform. However the micrometer showed it to be 1.05 mm. thick on one edge and 1.27 mm. thick on the other. The difference, 0.22 mm. Al, is exactly of the order of difference sought. The way in which this difference caused the variation found may be easily seen. Less radiation falls on the side of the film (the right hand half) beneath the thickest part of the filter; since the left hand film was always in an area of greater radiation the D.Rs. are greater than those on the right hand film. Furthermore, the teeth on the left side of the penetrometer in both films received more radiation than those on the right hand side which accounts for the "irregular" regularity of variation in the I.Vs. for tooth 2 (Fig. 8). Finally, the removal of the aluminum tube stand filter* eliminated this type of variation from subsequent films and improved the reproducibility of I.Vs. by about 20 per cent.

B. CASSETTE CARDBOARD FILTER

In some of the early work, a series of I.Vs. were obtained at 30, 40, 50, 60, 70 and 80 kv. which seemed to show an independence of I.Vs. *for dentine* when the voltage changed, although the error in reproducibility at that time was about 20 per cent. However, *for enamel* there appeared to be a sharply defined critical voltage (Fig. 9) above which the I.Vs. were fairly constant and below which the values decreased with decreasing kilovoltage. This critical voltage apparently lay between 40 and 50 kv. and as a consequence 55 kv. was stipulated as optimum for our study.

Further work and improved precision gave the results shown in Figure 10. I.Vs. for the dentine are constant whether taken at 31, 41, 51 or 61 kv. and are closely grouped around 0.80 mm. Al. I.Vs. for the enamel are about the same at 41, 51 and 61 kv., and are close to 1.4 mm. Al, however at 31 kv. there is a marked decrease to values grouped about 1.2 mm. Al. Thus

* If it is necessary or desirable to use an Al or any other tube stand filter, its uniformity of absorption of roentgen radiation should be experimentally ascertained. A tube free of metal deposit upon the glass should always be used.

the hypothesis that a critical voltage for the correct exposure of enamel existed between 40 and 50 kv. was laid aside. Instead it was proposed that the enamel really did decrease in its absorption relative to aluminum as the kilovoltage is decreased. From the theoretical mass absorption coefficient calculated on the basis of the chemical constitution of enamel, a decrease in the Al equivalent is prophesiable. However, it was proposed that the cardboard in the cassette should have a greater effect on the softer radiation at 30 kv. than on the harder radiation at higher kilovoltages and might be the cause for the marked difference in I.V. found. To test this hypothesis a series of films were wrapped in black paper of the sort used in protecting films in shipment and subsequently exposed as usual. It will be shown below that the cardboard cassette is found to be responsible for some of the decrease in the I.Vs. when the voltage is decreased from 40 to 30 kv. Thus, even in paper-wrapped films the average I.V. for enamel is found to be about 1.3 mm. Al at 30 kv. and 1.4 mm. Al at 40 kv., a difference due probably to the change in mass absorption coefficient of enamel relative to Al with change in kilovoltage (see later discussion on voltage change).

In order to study the effect of the cardboard cassette on the I.Vs. for enamel and dentine a series of films were exposed at 30 kv., 30 inch distance, 30 ma., no filter and 10 seconds, of which some of the films were paper-wrapped, others in a cardboard cassette. To check the effect of voltage change on I.Vs. from cardboard vs. paper-wrapped films, another series of films were made at 40 kv., 30 inches, 30 ma., no filter and 2 seconds' exposure. The results and conclusions follow.

I.V. at 30 kv. In Table VIII are given the D.Rs. in the various steps of the penetrometers in two films taken *with the ordinary cardboard cassette*, 32 kv., 15 inches, 30 ma., no filter and 2 seconds' exposure. The D-T curves are closely laid, coincident in the 4 thicker steps and similar to other D-T curves. The I.Vs. for the enamel are 1.23 and 1.24 mm. Al, for the dentine 0.78 and 0.76 mm. Al, in films 41 and 51 respectively.

In Table IX are given the D.Rs. in the various steps of the penetrometers in 6 films taken *with the ordinary cardboard cassette*, 32 kv., 30 inches, 30 ma., no filter and 10 seconds' exposure. The D-T. curves are of the usual logarithmic character and so closely placed that a span of 0.05 density units at any given thickness will include all six D-T curves. The I.Vs. for the enamel are 1.19, 1.23, 1.18, 1.23, 1.22 and 1.22 mm. Al, for the dentine 0.78, 0.80, 0.80, 0.77, 0.79 and 0.79 mm. Al in films 71, 72, 73, 74, 75 and 76, respectively. The eight I.Vs. from Tables VIII and IX are in satisfactory agreement among themselves, being on the average for the *enamel* 1.22 mm. Al with a gross variation of 4 per cent of the average; for the *dentine* 0.78 mm. Al with a gross variation of 4 per cent of the average.

TABLE X

BLACK PAPER, 1 THICKNESS, 32 KV., 30 INCHES, 30 MA., NO FILTER, 10 SECONDS

Film	Film 271		Film 272		Film 273		Film 274		Film 275	
Densitometer Readings										
Penetrometer	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*
Step 1	2.54–2.46	2.50–2.44	2.54–2.51	2.55–2.51	2.52–2.50	2.49–2.47	2.55–2.57	2.58–2.55	2.43–2.43	2.43–2.41
2	1.95–1.90	1.90–1.87	1.95–1.92	1.95–1.94	1.92–1.91	1.91–1.91	1.93–1.93	1.94–1.93	1.85–1.87	1.83–1.80
3	1.49–1.50	1.48–1.46	1.51–1.52	1.53–1.50	1.50–1.50	1.48–1.46	1.46–1.49	1.48–1.50	1.43–1.44	1.42–1.41
4	1.19–1.17	1.17–1.16	1.20–1.19	1.20–1.20	1.19–1.18	1.15–1.19	1.17–1.18	1.16–1.18	1.15–1.14	1.10–1.10
5	0.93–0.94	0.92–0.92	0.93–0.94	0.92–0.97	0.91–0.95	0.91–0.90	0.89–0.90	0.92–0.95	0.89–0.89	0.86–0.86
6	0.76–0.77	0.76–0.76	0.72–0.76	0.75–0.78	0.73–0.75	0.71–0.75	0.68–0.73	0.71–0.78	0.72–0.72	0.72–0.70
7	0.61–0.63	0.58–0.61	0.57–0.60	0.59–0.65	0.57–0.59	0.57–0.59	0.55–0.58	0.57–0.62	0.57–0.57	0.56–0.55
8	0.57–0.57	0.54–0.55	0.53–0.55	0.55–0.60	0.54–0.55	0.49–0.56	0.51–0.55	0.51–0.57	0.55–0.54	0.52–0.54
Enamel	—0.90		0.89		0.90		0.90		0.88	
Dentine	—1.47		1.47		1.48		1.48		1.42	
Interpolated Values										
Enamel	—1.30		1.32		1.28		1.28		1.27	
Dentine	—0.80		0.82		0.80		0.79		0.80	

Table x—*Continued*

Film	Film 276		Film 277		Film 278		Film 46	
Densitometer Readings								
Penetrometer	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*
Step 1	2.46–2.45	2.48–2.46	2.51–2.51	2.49–2.46	2.41–2.39	2.39–2.38	2.47–2.47	2.47–2.47
2	1.87–1.89	1.91–1.90	1.94–1.92	1.93–1.89	1.84–1.83	1.80–1.80	1.83–1.78	1.76–1.75
3	1.41–1.46	1.43–1.48	1.48–1.48	1.47–1.45	1.40–1.43	1.38–1.41	1.35–1.33	1.32–1.33
4	1.11–1.14	1.13–1.17	1.20–1.19	1.17–1.17	1.10–1.12	1.12–1.12	1.04–1.02	1.02–1.03
5	0.84–0.86	0.87–0.93	0.95–0.96	0.89–0.90	0.84–0.86	0.84–0.89	0.81–0.80	0.79–0.79
6	0.67–0.73	0.70–0.76	0.75–0.77	0.72–0.76	0.66–0.70	0.72–0.75	0.65–0.66	0.65–0.67
7	0.50–0.54	0.54–0.61	0.61–0.62	0.60–0.60	0.55–0.62	0.54–0.64	0.57–0.57	0.56–0.56
8	0.46–0.52	0.53–0.57	0.56–0.56	0.54–0.54	0.49–0.54	0.51–0.60	0.54–0.54	0.52–0.53
Enamel	0.89		0.90		0.88		0.74	
Dentine	1.46		1.49		1.39		1.35	
Interpolated Values								
Enamel	1.27		1.31		1.25		1.35	
Dentine	0.78		0.78		0.81		0.79	

In Table x are given the D.Rs. in the various steps of the penetrometers in 9 films taken *in a single wrapping of black paper*, at 32 kv., 30 inches, 30 ma., no filter and 10 seconds' exposure. The D-T curves are closely laid, intercrossing sometimes, coincident sometimes, logarithmic, typical. The I.Vs. for the enamel average about 1.3 mm. Al, for the dentine average about 0.80 mm. Al.

In Table xi are given the D.Rs. in the various steps of the penetrometers in 4 films taken *in a double wrapping of black paper*, at 32 kv., 30 inches, 30 ma., no filter and 10 seconds' exposure. The D-T curves are not so closely grouped as those for the data in Table xi, however these are at times coincident and on the whole typical, logarithmic curves. The I.Vs. for the enamel average about 1.35 mm. Al, for the dentine average about 0.8 mm. Al. The 13 I.Vs. from Tables x and xi are in satisfactory agreement, having an average value for the enamel of 1.31 mm. Al with a gross variation of 8 per cent of the average, for the dentine of 0.80 mm. Al with a gross variation of 5 per cent of the average. There is no apparent difference between the I.Vs. for the enamel and for the dentine whether the film is singly or doubly wrapped in black paper, consequently the safer procedure is adopted, i.e., the film is doubly wrapped in black paper in those experiments where "black paper" is stipulated as a condition of the exposure.

Summary. The average I.Vs. for the enamel and for the dentine which are obtained by identical exposure conditions except the wrapping of the film (*a*) in the ordinary cardboard cassette, (*b*) in black paper, are seen to be different. When the film is placed *in the cardboard cassette*, the average I.V. for the enamel is 1.22 mm. Al, for the dentine 0.78 mm. Al. When the

Table XI

Black paper, 2 thicknesses, 32 kv., 30 inches, 30 ma. no filter, 10 seconds

Film	Film 42		Film 43		Film 44		Film 45	
Densitometer Readings								
Penetrometer	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*
Step 1	2.23–2.19	2.23–2.23	2.11–2.09	2.07–2.05	2.35–2.33	2.31–2.37	2.35–2.37	2.38–2.35
2	1.56–1.55	1.60–1.63	1.49–1.44	1.43–1.45	1.67–1.69	1.69–1.70	1.68–1.69	1.70–1.70
3	1.19–1.16	1.19–1.19	1.09–1.10	1.09–1.09	1.31–1.29	1.28–1.27	1.30–1.28	1.27–1.26
4	0.89–0.89	0.90–0.90	0.83–0.80	0.81–0.82	1.00–0.99	1.00–1.02	1.00–0.98	0.97–1.00
5	0.71–0.70	0.69–0.68	0.63–0.60	0.64–0.65	0.81–0.78	0.75–0.80	0.74–0.77	0.76–0.77
6	0.58–0.54	0.54–0.55	0.54–0.54	0.52–0.54	0.62–0.63	0.60–0.65	0.63–0.61	0.61–0.64
7	0.48–0.47	0.47–0.46	0.48–0.45	0.46–0.48	0.52–0.53	0.53–0.54	0.51–0.50	0.50–0.54
8	0.43–0.41	0.46–0.46	0.44–0.43	0.43–0.47	0.47–0.50	0.50–0.52	0.47–0.47	0.46–0.49
Enamel	0.63		0.59		0.73		0.73	
Dentine	1.17		1.06		1.34		1.23	
Interpolated Values								
Enamel	1.36		1.36		1.34		1.32	
Dentine	0.79		0.82		0.82		0.83	

TABLE XII

BLACK PAPER, 44 KV., 30 INCHES, 30 MA., NO FILTER, 1½ SECONDS

FILM	Film 10		Film 11	
DENSITOMETER READINGS				
Penetrometer	*Left*	*Right*	*Left*	*Right*
Step 1	2.39–2.39	2.42–2.42	2.36–2.36	2.31–2.28
2	2.11–2.14	2.10–2.12	2.17–2.12	2.07–2.05
3	1.95–1.93	1.95–1.94	1.97–1.95	1.91–1.91
4	1.81–1.81	1.73–1.76	1.86–1.82	1.79–1.74
5	1.68–1.64	1.65–1.68	1.69–1.69	1.66–1.63
6	1.50–1.52	1.57–1.57	1.64–1.62	1.58–1.56
7	1.44–1.44	1.44–1.44	1.50–1.51	1.46–1.44
8	1.40–1.40	1.36–1.38	1.43–1.40	1.38–1.38
Enamel	1.61		1.62	
Dentine	1.91		1.93	
INTERPOLATED VALUES				
Enamel	1.36		1.43	
Dentine	0.83		0.82	

film is wrapped *in black paper*, the average I.V. for the enamel is 1.31 mm. Al, for the dentine 0.80 mm. Al. The increase in the average I.V. for the enamel from 1.22 to 1.31 mm. Al is of particular interest, since this increase brings the values at 30 kv. near the range of I.Vs. obtained at higher kilovoltages. Thus it may be deduced that there is no critical kilovoltage such as was originally postulated. The increase in the average I.V. for the dentine from 0.78 to 0.80 mm. Al is possibly a real change in the physical sense but since it is of less magnitude than the precision of the method, the increase is negligible.

I.V. at 40 kv. In Table XII are given the D.Rs. in the various steps of the penetrometers in 2 films taken wrapped *in black paper* at 44 kv., 30 inches, 30 ma., no filter and 1½ seconds' exposure. The D-T curves are placed high in the density range, sloped more nearly horizontal than D-T curves at the same kv. in lesser exposures, intercrossed. The I.Vs. for enamel average about 1.40 mm. Al, for dentine average about 0.82 mm. Al for films wrapped in black paper and taken at a peak kilovoltage of approximately 40.

TABLE XIII

1 CARDBOARD, 41 KV., 30 INCHES, 30 MA., NO FILTER, 2 SECONDS

FILM	Film IX		Film X		Film 62	
DENSITOMETER READINGS						
Penetrometer	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*
Step 1	2.21–2.17	2.11–2.06	2.07–2.06	2.06–2.07	2.17–2.17	2.17–2.20
2	1.80–1.74	1.74–1.73	1.72–1.69	1.70–1.69	1.85–1.83	1.84–1.87
3	1.50–1.50	1.44–1.45	1.45–1.43	1.43–1.42	1.57–1.57	1.58–1.60
4	1.30–1.28	1.26–1.24	1.22–1.22	1.23–1.25	1.37–1.38	1.36–1.39
5	1.13–1.13	1.08–1.07	1.07–1.07	1.07–1.07	1.21–1.20	1.21–1.22
6	0.99–0.97	0.95–0.95	0.91–0.93	0.91–0.92	1.07–1.06	1.04–1.11
7	0.86–0.86	0.80–0.81	0.78–0.79	0.81–0.81	0.92–0.94	0.90–0.94
8	0.76–0.77	0.69–0.70	0.72–0.72	0.72–0.70	0.84–0.84	0.82–0.87
Enamel	1.05		1.04		1.19	
Dentine	1.50		1.42		1.58	
INTERPOLATED VALUES						
Enamel	1.35		1.30		1.28	
Dentine	0.76		0.81		0.80	

TABLE XIV

2 CARDBOARD, 41 KV., 30 INCHES, 30 MA., NO FILTER, 2 SECONDS

FILM	Film XI		Film XII		Film 63	
DENSITOMETER READINGS						
Penetrometer	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*
Step 1	2.10–2.08	2.02–2.06	2.05–2.07	2.05–2.08	2.06–2.07	2.07–2.07
2	1.75–1.74	1.69–1.64	1.70–1.73	1.75–1.71	1.75–1.74	1.75–1.75
3	1.51–1.52	1.47–1.40	1.47–1.46	1.47–1.47	1.50–1.53	1.49–1.49
4	1.31–1.31	1.29–1.21	1.27–1.29	1.29–1.31	1.31–1.32	1.31–1.32
5	1.15–1.15	1.10–1.07	1.11–1.14	1.14–1.15	1.17–1.19	1.17–1.16
6	1.00–1.00	0.94–0.94	0.98–0.99	1.00–1.00	1.01–1.05	1.00–1.04
7	0.90–0.88	0.81–0.83	0.84–0.87	0.88–0.87	0.89–0.92	0.86–0.89
8	0.79–0.80	0.78–0.78	0.78–0.80	0.80–0.82	0.80–0.82	0.82–0.82
Enamel	1.11		1.11		1.17	
Dentine	1.49		1.50		1.49	
INTERPOLATED VALUES						
Enamel	1.28		1.31		1.26	
Dentine	0.77		0.76		0.81	

In Table XIII are given the D.Rs. in the various steps of the penetrometers in 3 films taken *in the ordinary cardboard cassette* at 41 kv., 30 inches, 30 ma., no filter and 2 seconds' exposure. The D-T curves are similar, logarithmic, typical and displaced slightly below the D-T curves for the paper-wrapped film. The I.Vs. for the enamel average about 1.31 mm. Al. for the dentine average about 0.79 mm. Al in films taken in the cardboard cassette; both average values are lower than in the paper-wrapped films.

In Table XIV are given the D.Rs. in the various steps of the penetrometers in 3 films taken *with 2 sheets of cardboard* between the tooth slab-penetrometers and the film at 41 kv., 30 inches, 30 ma., no filter and 2 seconds' exposure. The D-T curves are similar, logarithmic, typical and placed close to the D-T curves for the film in the cardboard cassette (Table XIII). The I.Vs. for the enamel average about 1.28 mm. Al, for the dentine about 0.78 mm. Al; both average values are lower than in paper wrapped or cardboard cassette protected films.

In Table XV are given the D.Rs. in the various steps of the penetrometers in 3 films taken *with 3 sheets of cardboard* between the tooth slab-penetrometers and the film at 41 kv., 30 inches, 30 ma., no filter and 2 seconds' exposure. The D-T curves are similar, logarith-

TABLE XV

3 CARDBOARD, 41 KV., 30 INCHES, 30 MA., NO FILTER, 2 SECONDS

FILM	Film XIII		Film XIV		Film 64	
DENSITOMETER READINGS						
Penetrometer	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*
Step 1	1.99–1.99	1.99–1.96	1.99–1.99	1.97–1.97	2.02–2.00	1.99–1.99
2	1.68–1.67	1.68–1.66	1.70–1.68	1.69–1.68	1.70–1.69	1.70–1.68
3	1.44–1.45	1.44–1.45	1.45–1.44	1.43–1.43	1.49–1.46	1.45–1.44
4	1.28–1.28	1.30–1.28	1.26–1.28	1.25–1.30	1.31–1.32	1.28–1.30
5	1.16–1.14	1.13–1.12	1.11–1.10	1.11–1.12	1.12–1.14	1.11–1.13
6	0.99–1.00	0.99–0.99	0.98–1.01	0.99–1.01	1.00–1.01	0.99–1.00
7	0.89–0.89	0.88–0.89	0.87–0.88	0.87–0.90	0.87–0.88	0.86–0.88
8	0.79–0.80	0.79–0.80	0.78–0.83	0.80–0.82	0.81–0.81	0.76–0.80
Enamel	1.15		1.14		1.13	
Dentine	1.49		1.47		1.46	
INTERPOLATED VALUES						
Enamel	1.24		1.23		1.24	
Dentine	0.75		0.78		0.81	

mic and closely placed to the D-T curves for the single and double cardboard covered films (see Tables XIII and XIV). The I.Vs. for the enamel average about 1.24 mm. Al, for the dentine about 0.78 mm. Al, both average values are lower than in paper-wrapped films.

Summary. At 40 kv. the average I.Vs. for the enamel are (*a*) 1.40, (*b*) 1.31, (*c*) 1.28, (*d*) 1.24 mm. Al; for the dentine are (*a*) 0.82, (*b*) 0.79, (*c*) 0.78, and (*d*) 0.78 mm. Al in films taken respectively in (*a*) paper-wrapped, (*b*) in the cardboard cassette, (*c*) with 2 sheets and (*d*) with 3 sheets of cardboard between the tooth slab-penetrometers and the film. For the enamel the average I.Vs. are less in the cardboard protected films than in the paper-wrapped film exactly as was noted for similar conditions in films taken at 30 kv. Additional sheets of cardboard decrease the I.Vs. for the enamel but the second and third sheet produce smaller decreases in the I. Vs. than the first sheet. For the dentine the decrease in the average I.V. from 0.82 mm. Al in paper-wrapped films to about 0.78 mm. Al in the cardboard protected films is exactly similar to the decrease observed at 30 kv. under similar conditions. Two or three sheets of cardboard are observed to have little more effect than the single sheet in the usual cardboard cassette.

CONCLUSION

The average I.V. (interpolated value) for enamel is less in a film protected by cardboard than in a paper-wrapped film, both at 30 and at 40 kv. In order to increase the reproducibility of the method the films are wrapped in black paper in subsequent experiments.

GENERAL SUMMARY AND CONCLUSIONS

1. There should be as little material as possible, and this must be of uniform density and thickness, between the target of the roentgen tube and the film in order to reduce the errors of this method to the lowest level. It is best to eliminate all tube stand filters and use a fairly new tube.

2. The film should be wrapped in two thicknesses of clean black paper (such as that enclosing roentgen film in the standard packages).

3. Any variation of the above must be tested for errors in any quantitative study. These may be found best by a study of the reproducibility of the technique.

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Thirty-seventh Annual Meeting: Cleveland, Ohio, 1936.

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Janeway Lecture Committee: Douglas Quick, Chairman, New York City.

Committee on Arrangements: E. H. Skinner, Chairman, Kansas City, Mo., E. K. Robinson, Kansas City, Mo., W. R. Brooksher, Fort Smith, Ark.

Twenty-first Annual Meeting: Kansas City, Mo., May 11–12, 1936.

EDITORIAL

THE THIRTY-SIXTH ANNUAL MEETING

THE annual meeting of the American Roentgen Ray Society is always a source of pleasure and profit to those who attend but it is doubtful if in the whole thirty-six years of the Society's existence there has been a better meeting than the one recently held in Atlantic City. The meeting place, the weather, the character of the program and the orderly fashion in which the daily scientific program was executed all contributed greatly to the success of this meeting. President-elect Hodges and his program committee are to be felicitated on the scope and quality of the papers and above all upon the expeditious manner in which they were presented. Heretofore the program has always carried the injunction that the papers would be limited to fifteen minutes but never before in our memory has this injunction been strictly adhered to. The assembly hall was at all times filled with members of the Society and their guests and the close of the morning and afternoon sessions came all too quickly. It has always been difficult to understand why scientific meetings should at times be so conducted as to produce a definite sense of mental and physical fatigue as happens not infrequently. This meeting was entirely devoid of such an experience all because of the dispatch with which the papers were given.

Another very wholesome aspect of the meeting was the innovation of adjourning the meeting at certain periods during the day to permit those in attendance to thoroughly study the scientific exhibits, and the exhibits themselves justified such an arrangement. It may be said without contradiction that never in the whole history of the Society has there been a more comprehensive and instructive group of exhibits than at this meeting, the value of the exhibits being greatly enhanced by the presence of the exhibitors who graciously explained the purpose and import of their exhibits. Then, too, most of the papers read in the scientific session were amplified in the exhibit section. This is a feature which might well be followed at future annual meetings.

The technical or commercial exhibit at this meeting was up to the usual standard and it was distinctly noticeable that many of the exhibitors had new display boxes for exhibiting their machinery and accessories which added greatly to the arrangement of the exhibit. The Society wishes through its Journal to express its thanks to the commercial exhibitors for their participation in this year's meeting.

The usual social functions which are always a pleasant feature proved to be unusually so this year, due perhaps to the whole temper of the meeting. The Caldwell Lecture was given by Dr. J. Shelton Horsley of Richmond whose subject was "The Relationship between Surgery and Radiology," a relationship which has been more or less intimate since the beginning of roentgenology as most of the departments of roentgenology in the older hospitals were established as ancillary departments in the surgical division of the hospital, and only in these latter years has the department of roentgenology grown into its proper place of copartnership with medicine and surgery. The banquet on Thursday evening was one of the enjoyable episodes of the meeting, thanks to the arrangements of the Local Committee headed by Dr. W. C. Wescott.

Those who have to do in the future with the planning and execution of the program for the annual meeting can take as their example and pattern the recent meeting in Atlantic City. To the officers and personnel of Haddon Hall the Society is deeply grateful for their splendid cooperation in adding to what might be described as a well nigh perfect meeting.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. E. P. Pendergrass, University Hospital, Philadelphia, Pa. Annual Meeting: Cleveland, Ohio, 1936.

American College of Radiology
Secretary, Dr. B. H. Orndoff, 2561 N. Clark Street, Chicago, Ill. Annual meeting: Kansas City, Mo., 1936.

Section on Radiology, American Medical Association
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: Kansas City, Mo., 1936.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N.Y. Annual meeting: Detroit, Mich., Dec. 2–6, 1935.

Radiological Section, Baltimore City Medical Society
Secretary, Dr. W. B. Firor, 1100 N. Charles St., Baltimore. Meets third Tuesday each month, September to May.

Radiological Section, Connecticut State Medical Society
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets annually in May. Special meetings may be called by the Chairman.

Radiological Section, Los Angeles County Medical Society
Secretary, E. N. Liljedahl, Los Angeles, Calif. Meets on the fourth Wednesday of each month at the California Hospital.

Radiological Section, Southern Medical Association
Secretary, Dr. H. J. Walton, 104 W. Madison St., Baltimore, Md. Annual meeting, St. Louis, Mo., Nov. 19–22, 1935.

Brooklyn Roentgen Ray Society
Secretary, Dr. E. Mendelson, 120 E. 19th St., Brooklyn, N.Y. Meets monthly on first Tuesday, October to April.

Buffalo Radiological Society
Secretary-Treasurer, Dr. A. W. Thompson, 135 Linwood Ave., Buffalo, N.Y. Meets second Monday of each month except during summer months, place of meeting selected by the host.

Chicago Roentgen Society
Secretary, Dr. R. G. Willy, 1138 N. Leavitt. Meets second Thursday of each month October to May inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. H. G. Reineke, General Hospital, Cincinnati, Ohio. Meets third Monday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, North W. Shetter, M.D., 14600 Detroit Ave. Meetings are held at 6:30 P.M. at the Cleveland Chamber of Commerce Club rooms on the fourth Monday of each month from October to April, inclusive.

Denver Radiological Club
Secretary, Dr. K. D. A. Allen, 452 Metropolitan Building, Denver, Colorado. Meets on any month having a fifth Monday.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne Country Medical Society Building.

Florida State Radiological Society
Secretary, Dr. Gerard Raap, Miami, Florida. Meetings held twice a year, May and November.

Illinois Radiological Society
Secretary, Dr. H. W. Grote, 219 N. Main St., Bloomington, Ill. Regular meetings held quarterly.

Indiana Roentgen Society
Secretary, Dr. J. N. Collins, Indianapolis, Ind. Meeting held the second Sunday in May annually.

Long Island Radiological Society
Secretary, Dr. M. Dannenberg, 1464 Eastern Parkway, Brooklyn, N. Y. Meets on third Thursday of each month from October to May, at 8:30 P.M.

Michigan Association of Roentgenologists
Secretary, Dr. S. W. Donaldson, St. Joseph's Mercy Hospital, Ann Arbor, Mich. Three meetings a year, Fall, Winter, and Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. S. A. Morton, Columbia Hospital, Milwaukee, Wis. Meets monthly. Place of meeting designed by the president.

Minnesota Radiological Society
Secretary, Dr. L. G. Rigler, University Hospital, Minneapolis, Minn.

New England Roentgen Ray Society
Secretary, Dr. Thomas R. Healy, 370 Marlboro St., Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

Radiological Society of New Jersey
Secretary, Dr. P. S. Avery, New Brunswick, N. J. Meets annually at time and place of State Medical Society. Mid-year meetings at place designated by the president.

New York Roentgen Society
Secretary, Dr. E. F. Merrill, 30 W. 59th St., New York. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse, N.Y. Three meetings a year—January, May, and November.

Pacific Roentgen Club
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, Williamsport, Pa.

Philadelphia Roentgen Ray Society
Secretary, Dr. Thomas Loughery, Germantown Hospital. Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Rochester Roentgen Ray Society, Rochester, N.Y.
Secretary, Dr. W. W. Fray, Strong Memorial Hospital. Meets monthly on second Thursday from October to May, inclusive, at 7:45 at the Rochester Medical Association Building.

St. Louis Roentgen Ray Society
Secretary, Dr. P. C. Schnoebelen, Missouri Bldg., St. Louis, Mo. Meets first week of each month. Time and place of meetings designated by president.

South Carolina X-Ray Society
Secretary, Dr. R. B. Taft, 105 Rutledge Ave., Charleston. Meets at time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. F. B. Bogart, 311 Medical Arts Bldg.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary-Treasurer, Dr. J. H. Smith, Lubbock, Texas.
Meets annually one day preceding the meeting of the Texas State Medical Association.

University of Michigan Department of Roentgenology Staff Meeting
Secretary, Dr. C. B. Peirce, University Hospital, Ann Arbor, Mich.
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Roentgen Club
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis.
Meets monthly on last Thursday, October to April, Service Memorial Institute, at 4:30 P.M.

Virginia Roentgen Ray Club
Secretary, Dr. V. W. Archer, University Hospital, University, Va.
Meets annually in October.

Cuba

Sociedad Cubana de Radiologia y Fisioterapia
Secretary, Dr. Francisco Padron, Enrique, Villuendas 64, Havana, Cuba. Meets monthly in Havana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets on the third Thursday of each month, from November to June inclusive, at 8:15 P.M., at 32 Welbeck St., London, W. 1, or as advertised.

Electro-Therapeutic Section of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:30 P.M. at the Royal Society of Medicine, 1 Wimpole St., London, W. 1.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Colin Macdonald, Lister House, 61 Collins St., Melbourne, Australia.
Meets monthly at Melbourne during the winter.

Section on Radiology, Canadian Medical Association
Secretary, Dr. A. H. Rolph, 160 St. George St., Toronto, Ont.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. P. C. Fenwick, The Hospital, Christchurch. Meets annually.

Continental Europe

Belgian Society of Roentgenology
Secretary, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

Société de Radiologie Médicale de France
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean, La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel.
Meets annually in different cities.

Société Francaise d'Electrothérapie et de Radiologie Médicale.
Meets monthly on fourth Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Association of German Roentgenologists and Radiologists in Czecho-Slovakia
Secretary, Dr. Walter Altschul, German University, Prague, II.52.

Deutsche Röntgen-Gesellschaft (Gesellschaft für Röntgenkunde und Strahlenforschung)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

Süd- und Westdeutsche Röntgengesellschaft
Meets annually in different cities.

Nord- und Ostdeutsche Röntgengesellschaft
Meets annually in different cities.

Dutch Society of Electrology and Roentgenology
Holds two meetings a year in Amsterdam, one in the Spring, and one in the Fall.

Societa Italiana Radiologia Medica
Secretary, Professor M. Ponzio, University of Turin, Turin.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Virgil Ionescu, B-dul Schitu Măgureanu 49, Bucarest.
Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson.
Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin.
Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky.
Meets monthly on the first Monday at 8 o'clock, the place of meeting being selected by the Society.

Polish Society of Radiology
Secretary, Dr. Jan. Kochanowski, 45 Gornoslazka St., Warsaw. Meets annually.

Warsaw Section, Polish Society of Radiology
Secretary, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summertime.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime.

Society of Medical Radiology in Sweden
Meets in Stockholm.

Society of Medical Radiology in Norway
Meets in Oslo.

Society of Medical Radiology in Denmark
Secretary, Dr. G. Biering, Copenhagen.
Meets on the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

Society of Medical Radiology in Finland
Meets in Helsingfors.

Vienna Roentgen Society
Meets first Wednesday of each month, at 6.30 P.M. at Zentral-Röntgen Institut des allgemeinen Krankenhauses Alserstrasse 4.

Orient

Japan X-Ray Association
c/o Orthopedic Surgery, Tokyo Imperial University.
Meets annually in April.

Kinki Roentgen-Abend Society
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto, Japan. Meets bi-monthly on third Sunday.

THE SCIENTIFIC EXHIBIT

THE scientific exhibit at the Thirty-sixth Annual Meeting of the American Roentgen Ray Society in Atlantic City was in perfect keeping and harmony with the scientific program in the subject matter, the disposition of the exhibits and the innovation of allotting time for their inspection. The Committee on Scientific Exhibit composed of Dr. W. E. Chamberlain, Chairman, Dr. E. E. Downs and Dr. S. W. Donaldson are to be congratulated upon the high standard of the exhibits. Perhaps never in the Society's history has the quality and scope of the exhibits been surpassed and then too the new illuminating boxes added considerably to the pleasure of examining the exhibits. It may be judged from this following rather cursory discussion of the scientific exhibits that the Committee on Awards composed of Dr. P. F. Butler, Chairman, Dr. H. E. Ashbury and Dr. Wm. H. Stewart had considerable difficulty in making a decision as to which exhibits deserved special mention.

Among the exhibits on bones and joints was one by Dr. Robert P. Ball, Baroness Erlanger Hospital, Chattanooga, Tenn., dealing with "Roentgen Pelvimetry and Fetal Cephalometry." The exhibit contained films, charts and diagrams showing a new method of pelvimetry. The size of the fetal cranium is measured by tracing the perimeter of the roentgen image. The volume of the fetal skull is determined and compared with the volume capacity of the smallest pelvic diameter. Anteroposterior and lateral roentgenograms of the pelvis only are used to obtain these measurements. The patient is not measured and no markers are used on the patient. A calculator to correct roentgen-ray magnification is used. This method seemed to be one of extreme importance in that it is so easy of application. The quality of this exhibit was such that it was awarded a Certificate of Merit.

Another exhibit on "Roentgenologic Studies of the Female Pelvis and the Fetal-Pelvic Relationship during Labor" was given by Dr. Paul C. Swenson, Presbyterian Hospital, New York City. By the use of half-tone illustrations, mounted specimens and films, the common pelvic types were demonstrated, and by means of roentgen films obtained during labor, the mechanism of labor in relationship to the pelvic types were shown. The practical application of the precision stereoscope of use in mensuration of the pelvis and a study of the fetal-pelvic relationships were shown in this exhibit.

Dr. Ralph S. Bromer, Dr. Joseph Stokes, Jr., and Dr. Milton Rapaport, Children's Hospital, Philadelphia, had a very comprehensive exhibit on the "Early Roentgen Signs of Rickets in the Long Bones."

A very important exhibit calling attention to the normal development of the epiphyses in the sacroiliac joints and their disturbance during adolescence was given by Dr. Edwin N. Cleaves, Boston. The importance of the adolescent sacroiliac joints in their relation to epiphysitis was called attention to editorially in the September issue of the Journal.

Dr. Ralph K. Ghormley of the Mayo Foundation, Rochester, Minn., had a very instructive exhibit on the "Study of the Synovial Membranes in Various Types of Arthritis by Differential Stains." Roentgenograms and photomicrographs together with abstracts of histories illustrating his paper were given. In addition to Dr. Ghormley's personal demonstration of this exhibit he gave a very instructive and comprehensive paper on the same subject.

The exhibit of Dr. Charles L. Martin, Baylor University Hospital, Dallas, Texas, on "Bone Metastases Treated by Castration" was very illuminating. Films were presented showing the recalcification of metastases in the metastatic areas in the bones in patients who had cancer of the breast. This exhibit also supplemented Dr. Martin's very comprehensive paper on castration in carcinoma.

Dr. Sherwood Moore, Washington University School of Medicine, St. Louis, Mo., had an exhibit on "Metabolic Craniopathy" which supplemented his paper on this subject given in the scientific session.

Dr. Maurice M. Pomeranz, Hospital for Joint Diseases, New York City, had a splendid exhibit on "Bone Changes in Certain Metabolic Disorders." Numerous films were exhibited illustrating the various bone and joint changes in metabolic disturbances. Among these were some of unusual and rare lesions.

Another exhibit of "Interesting and Unusual Bone Lesions, Primary and Metastatic Malignant Tumors of Bone and Similar Allied Lesions" was given by Dr. Nathaniel H. Robin, Dr. Percival A. Robin and Dr. O. C. Hudson, Hempstead, New York.

Among the most interesting exhibits of the entire meeting was the one given by Dr. O. H. Perry Pepper, University of Pennsylvania Hospital, Philadelphia on "Hereditary Occurrence of Enlarged Parietal Foramina." Dr. Pepper called attention to the fact that the parietal foramen occurs inconstantly; it is seldom larger than 2 mm. in diameter. A few dozen skulls are recorded with parietal foramina of such size as to admit a finger. Only in a very few instances has the anomaly been recognized during life. Its occurrence in two brothers and in five generations of another family are on record. His report concerned the anomaly in two additional families studied during life. He also pointed out the fact both in his paper and in the exhibit that the anomaly seldom causes symptoms. It is important that it be recognized and not confused with defects in the skull from other causes. Dr. Pepper's paper and exhibit both provoked considerable interest and discussion.

In the realm of diseases of the chest there were a number of interesting scientific exhibits, among which was the one given by Dr. Vincent W. Archer, University of Virginia Hospital, University, Va., on "The Roentgenologic Pulmonary Findings in Tularemia." His exhibit was quite comprehensive showing that definite pulmonary changes may be demonstrated by the roentgen ray in a high percentage of cases of tularemia and that the changes in the active cases are: (1) pneumonia, with or without necrosis; (2) pleural effusion; (3) nodular infiltration; (4) peribronchial thickening. The residual changes obtained in the roentgenogram are: (1) increased fibrosis; (2) an apparent increase in calcification. In the personal demonstration of his exhibit, Dr. Archer advised that every chest presenting atypical findings occurring in tularemic territory should have the benefit of the agglutination test, and since tularemia has such a widespread distribution the roentgenologist should familiarize himself with Dr. Archer's recent report on this condition.

The exhibit by Dr. Aubrey O. Hampton and Dr. Donald S. King, Massachusetts General Hospital, Boston, on the "Roentgen Appearance of the Right Middle Lobe of the Lung in Health and Disease" was a most instructive and comprehensive one. The material from which the exhibit was prepared was selected from lateral roentgenograms of the chests of 62 patients with middle lobe disease. The members of the Society who failed to avail themselves of the opportunity of seeing this exhibit missed a most instructive treat. This exhibit was awarded a Certificate of Merit.

Dr. George Levene, Massachusetts Memorial Hospital, Boston, gave a splendid exhibit on the "Roentgenoscopic Appearance of the Heart Shown by Working Models." This exhibit comprised a series of ten working mechanical models showing the appearance of the heart in health and disease. The exhibit included the normal heart, one showing sinus arrhythmia, another extrasystoles, others auricular fibrillation, heart block, thyrotoxicosis, coronary disease, aortic stenosis, aortic insufficiency, tricuspid insufficiency. The originality, character and instructiveness of this exhibit justified the Committee on Scientific Award in giving this exhibit the Silver Medal.

An exhibit by Dr. F. Maurice McPhedran, The Henry Phipps Institute, Philadelphia, on "The Pathogenesis of Tuberculosis and its Relation to Prognosis and Treatment" was a very interesting one comprising serial films in the course of (1) uncomplicated tuberculous lesions, (2) uncomplicated nontuberculous lesions, and (3) associated tuberculous and nontuberculous lesions. In the last group it was shown that exacerbations of nontuberculous lesions, characteristically occupying the cardiophrenic angle, are commonly accompanied or followed by retrogression of the associated tuberculous lesions. He called attention to the fact that this is seen in patients of all ages, both sexes, white and colored, and has occurred conspicuously in unselected cases of retrogression and healing of severe lesions in the absence of treatment. This exhibit supplemented Dr. McPhedran's interesting paper on the same subject given in the scientific session.

An exhibit by Dr. Carleton B. Peirce, University of Michigan Hospital, Ann Arbor, Mich., on "Lymphoblastoma: Hodgkin's Type" included specimen cases presenting the various roentgen changes of intrathoracic lymphoblastoma of the Hodgkin type. This exhibit supplemented Dr. Peirce's paper given in the symposium on lymphoblastoma in the scientific session.

An exhibit of considerable interest was the one by Dr. Coleman B. Rabin, Mt. Sinai Hospital, New York City, on "Roentgen Criteria for the Operability of Lung Tumors." This exhibit also served to illustrate Dr. Rabin's paper on this subject given in the scientific session.

An exhibit on "Miscellaneous Chest Conditions" was given by Dr. George S. Reitter of East Orange, N.J. His exhibit was of interest because most of the cases exhibited showed somewhat unusual manifestations.

In the section of the exhibit dealing with the gastrointestinal tract, the one on "The Small Intestine" by the Department of Radiology, the Department of Gastroenterology, the Department of Research Surgery, and the Department of Physiological Chemistry, University of Pennsylvania Hospital and School of Medicine, Philadelphia, was of such merit as to justify the committee's awarding it the Gold Medal. It is impossible in a short abstract even to call attention to the high lights of this exhibit, and the value and quality of the exhibit was greatly enhanced by the personal demonstration by the members of the faculty of the University of Pennsylvania Hospital and School of Medicine. The exhibit included charts and roentgen films showing the physiology, chemistry and pathology of the small intestine, including the physical, chemical and roentgenologic observations on the experimental animal and man and apparatus working in the human being and in the dog with chimographic tracings, charts and tubes and roentgenographic illustrations. The exhibit supplemented the symposium on research work on the small intestine given by Drs. Miller and Karr, Drs. Abbott and Pendergrass, and Drs. Ravdin, Johnston and Pendergrass. The papers dealing with the subject, as well as all of the papers given in the scientific session, will be published subsequently in the Journal.

Dr. J. Gershon-Cohen and Dr. A. J. Cohen, Eagleville Sanatorium, Eagleville, Pa., had a very comprehensive exhibit on "Ileocecal Tuberculosis" and Dr. Karl Kornblum and Dr. Wendell C. Hall of the Graduate Hospital and University of Pennsylvania Hospital, Philadelphia, had an exhibit illustrating the "Roentgenologic Significance of 'Milk of Calcium' Bile."

The exhibit by Dr. Oscar V. Batson and Dr. LeRoy M. Ennis, University of Pennsylvania, Philadelphia, on "A Roentgenological and Anatomical Study of the Maxillary Sinus" was of particular interest, illustrating the point that no matter how frequently a given subject may be studied there are often new angles of approach. This exhibit also served to illustrate the paper by Drs. Batson and Ennis given in the scientific session.

In the division of the exhibit dealing

with the genitourinary tract there were several exhibits of importance including one given by Dr. Eugene Freedman and Dr. James Joelson, University Hospitals, Cleveland, Ohio, on "Roentgen Diagnostic Problems of Pelvic Ureteral Stones." This exhibit dealt with cases demonstrating the difficulty of recognition of ureteral stones which overlap the bony parts of the pelvis. The exhibit served to emphasize the importance of films being taken with fine focus roentgen tubes which may show stone shadows that a broad focus tube does not visualize. Minute lower ureteral stones were shown in some of the films and the differentiation between phleboliths and ureteral stones was demonstrated. The exhibit also pointed out the value of serial examinations of the lower urinary tract in suspected ureteral calculi.

An exhibit given by Dr. H. Dabney Kerr and Dr. C. L. Gillies, Department of Radiology, State University of Iowa, Iowa City, Iowa, on the "Roentgen Diagnosis of Lesions of the Lower Urinary Tract" called attention to the fact that roentgen examinations of the upper urinary tract by means of contrast substances has become a routine procedure, but the lower urinary tract, which is even more accessible, has received surprisingly little attention. Their exhibit called attention to the simplicity of the procedures which are unattended by danger or discomfort and that the information elicited is comparable to that obtained by cystoscopy and it has the added advantage of leaving a permanent record. The contrast media employed as illustrated in this exhibit were those of lessened density or air, and second, those of greater density or sodium iodide. Exposures were made in both the anteroposterior and oblique positions. The films in their exhibit showed clearly the value of this sort of examination in the diagnosis of lesions of the bladder, prostate and urethra, such as bladder neoplasms, diverticula, and non-opaque calculi; prostatic hypertrophy and malignancy; urethral obstruction and para-urethral abscess.

An exhibit on "Common Renal Lesions —Differential Diagnosis of Pyogenic Infections, Tuberculosis and Malignancy" was given by Dr. R. Manges Smith, Dr. C. J. Bucher and Dr. T. R. Fetter, Jefferson Medical College Hospital, Philadelphia, and Drs. J. M. Hundley, Jr., Walton, Hibbitts, Siegel and Brack of the University of Maryland and Johns Hopkins University, Baltimore, had a splendid exhibit on "Physiological Changes Occurring in the Urinary Tract during Pregnancy." This exhibit served to illustrate Dr. Walton's paper on this subject given in the scientific session.

The exhibit of Dr. Cornelius G. Dyke, Neurological Institute of New York, on "The Roentgen Diagnosis of Spinal Cord Tumors" served to call attention to the frequency of spinal cord tumors and also to emphasize the fact that these tumors produce changes in the vertebral column which may be shown roentgenographically. This exhibit served to amplify Dr. Dyke's paper on this subject and also received a Certificate of Merit from the Committee on Scientific Award.

Dr. Milton Friedman and Dr. Rita Finkler of the Newark Beth Israel Hospital, Newark, N.J., and Sydenham Hospital, New York City, had an exhibit on "Benign Hyperplasias and Neoplasms of the Breast, Their Etiology, Pathology, Treatment by Endocrine and Radiation Therapy." This exhibit comprised charts, photographs, microphotographs and curves of quantitative endocrine determinations.

Dr. F. W. Konzelmann and Dr. B. R. Young, Temple University Hospital, Philadelphia, had an exhibit on "The Correlation of Pathologic Histology and Radiology in Neoplastic Diseases." This exhibit consisted of roentgenograms, photographs of patients, photomicrographs and gross specimens of various neoplastic diseases.

Among the miscellaneous exhibits was one on "Subdural Air Insufflation" by Dr. Campbell Howard, Flower Hospital, New York City; another on "What the Radiologist should know about Clinical Pathol-

ogy" by Dr. Karl Kornblum and Dr. Henry J. Tumen, Hospital of Graduate School of Medicine of the University of Pennsylvania, Philadelphia. The exhibit was designed to acquaint the radiologist with the significance of the more commonly employed tests and examinations used in the clinical investigations of patients frequently referred to the radiologist. Another exhibit under the miscellaneous section was one by Dr. R. S. E. Murray, U.S.V. Hospital, Lyons, N. J., showing bilateral reduplication of the ureter with accessory lobulation of both kidneys and another film showing calcification of the choroid plexuses.

An exhibit entitled "Encephalography Using Thorium Dioxide" was presented by Dr. Claude Moore, Dr. Walter Freeman and Dr. Herbert Schonfeld, Washington, D. C. Encephalograms were shown in which thorium dioxide was used as a contrast medium for the diagnosis of intracranial disease.

In the section dealing with therapy there was given an exhibit by Dr. Richard Dresser, Huntington Memorial Hospital, Boston, on "Treatment of Cancer of the Skin by High Voltage Roentgen Rays" and "Treatment of Cancer of the Eyelid." In this exhibit was illustrated the special technique for irradiation of cancer of the eyelid, with photographs before and after treatment and also a series of photographs showing large cancers of the skin treated by 200,000 volt roentgen rays.

Dr. Gordon E. Richards, Toronto, Canada, had an exhibit on "Radiotherapy in Ophthalmology." This comprised a number of cases of lesions in and about the orbit which had been treated successfully by radiation therapy. This supplemented Dr. Richards' paper of the same title read in the scientific session.

Dr. Otto Glasser and Dr. I. E. Beasley, Cleveland Clinic Foundation, Cleveland, Ohio, had an exhibit entitled "The Release of Ultraviolet Radiation from Roentgenized Substances by Visible Light." The exhibit consisted of a Geiger-Mueller photoelectric counter which is highly sensitive to ultraviolet radiation but hardly responds to visible light. Extremely weak sources of ultraviolet still produce discharges in the counter which can be amplified to such a degree that they can be heard on a loud speaker. Such weak sources of ultraviolet radiation are various salts following their exposure to and their removal from exposure to roentgen or gamma rays. Illumination of such salts with visible light greatly increases the number of discharges. This effect was demonstrated in the exhibit with salts which had been irradiated for various lengths of time, some of them as far back as February, 1935. This exhibit supplemented their paper given in the scientific section.

Dr. T. Leucutia and Dr. K. E. Corrigan, Department of Roentgenology, Harper Hospital, Detroit, Mich., had an exhibit on the "Technique and Comparative Value of Superhigh Voltage Roentgen Therapy." This exhibit showed physical data pertaining to measurement and radiation technique as well as illustrative clinical cases comparing the value in deep roentgen therapy (200 kv.) and superhigh voltage roentgen therapy (500 kv. and more).

Dr. Edward Rose and Dr. John H. Harris, University of Pennsylvania Hospital, Philadelphia, had an exhibit on "Radiation Therapy in Hyperthyroidism." This exhibit comprised charts, graphs and placards illustrating clinical types of hyperthyroidism best suited for radiation therapy; results of treatment—classification, relative to age, type of goiter, duration of disease, dosage, follow-up period; technique; graphic illustration of various types of response; advantages and disadvantages of irradiation.

Dr. Charles B. Ward, Dr. John Wirth and Dr. John Rose, Swedish Hospital, Seattle, Wash., had an exhibit on "Preliminary Report on the Results of 800 kv. Therapy." This supplemented the paper by Dr. Ward on the same subject.

In the section on tumor symposium was an exhibit by Dr. Harry H. Bowing, Mayo

Clinic, Rochester, Minn. on "Carcinoma of the Cervix Uteri, Treated with Radium Employing the Broken Dose Method." This exhibit illustrated among other things (1) the malignant disease problem; (2) historical structure of radiation therapy in gynecology; (3) a method of classification of patients with carcinoma of the uterine cervix; (4) a method of recording the value of the radium treatment applied; (5) a brief discussion of various radium therapy techniques, and advantages of the broken dose method; (6) the broken dose radium therapy technique employed at the Mayo Clinic; (7) supplemental roentgen-ray therapy; (8) sketches to illustrate the immediate and late results; (9) a series of charts to show late results obtained during the first decade of radium therapy (1915–1925) at the Mayo Clinic.

Dr. Wright Clarkson and Dr. Allen Barker, Petersburg, Va., had an exhibit entitled "Five Year Cure of Mammary Carcinoma with Multiple Metastases to Bone."

There was an exhibit on "A Study of the Carcinoma of the Cervix by Drs. Tehan, Downs, Hastings and Wammock, Jeanes Hospital, Philadelphia. The illustrations in this exhibit were unusually fine. There was a statistical analysis of a series of cases of carcinoma of the uterine cervix, showing clinical, pathological, and roentgenological observation and present method of treatment. The value of the exhibit was considerably augmented by graphs, charts and drawings showing the signs and symptoms, histological and clinical gradation, metastases and complications of this type of tumor. This exhibit was given the Bronze Medal by the Committee on Scientific Award.

Dr. Robert B. Taft, Charleston, S.C., had an interesting exhibit entitled "Lost and Found Radium." In this were included photographs, newspaper clippings, letters and diagrams showing the numerous difficulties encountered and the various methods employed in recovering lost radium.

OFFICERS ELECTED

The following officers were elected for the year 1935–1936 at the recent annual meeting of the American Roentgen Ray Society in Atlantic City: President: Dr. Fred M. Hodges, Richmond, Va.; President-Elect: Dr. Charles A. Waters, Baltimore, Md.; First Vice-President: Dr. Bernard H. Nichols, Cleveland, Ohio; Second Vice-President: Major John J. Moore, San Francisco, Calif.; Secretary: Dr. Eugene P. Pendergrass, Philadelphia, Pa.; Treasurer: Dr. Edward L. Jenkinson, Chicago, Ill.; Historian: Dr. Percy Brown, Boston, Mass.

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DEPARTMENT OF TECHNIQUE

Department Editor: Robert B. Taft, M.D., M.S., 105 Rutledge Ave., Charleston, S. C.

A CHAIR FOR ROENTGEN TREATMENT THROUGH THE PERINEUM

By ARTHUR U. DESJARDINS, M.D.,
Section on Therapeutic Radiology, The Mayo Clinic
ROCHESTER, MINNESOTA

IN GIVING treatment with roentgen rays for cancer of the uterus, cancer of the rectum, or for other tumors within the pelvis, it is often desirable to increase as much as possible the total depth dose delivered to the region occupied by the tumor. This is commonly done by increasing the number of fields of irradiation. With patients of average size, four fields constitute the maximum number through which irradiation is usually or can effectively be carried out. When a greater number of fields is required to deliver a sufficiently large total depth dose, and the size of the patient does not allow this to be done by increasing the number of anterior, posterior, and lateral fields, the only remaining possibility is to irradiate through a perineal field. Until now, unfortunately, irradiation through a perineal field has not been easy. The lack of flexibility of tube holders, the obesity of the patient, or the difficulty of maintaining the patient in position for satisfactory perineal irradiation, has led many radiologists to give up the idea or not to consider it at all.

With the advent of more flexible, shockproof tube holders, which make it possible to rotate the tube from a downward vertical to an upward vertical position, the problem of satisfactory perineal irradiation, regardless of the size of the patient, was greatly simplified. All that was required was a chair that provided suitable access to the perineum from below.

The accompanying illustrations show a chair (Figs. 1, 2, and 3) which I, with the able coöperation of our mechanical engineer, Mr. George Little, have designed for this purpose. Figure 4 gives certain details not shown in the photographs. As may readily be seen, the chair is made of heavy tubing, reënforced by double tubing at points of greatest stress. Folding steps (*S*) permanently attached to the upright members of the chair enable the patient to mount the chair readily, and the top step serves as a foot rest during treatment.

Fig. 1. Chair with steps down and with tube holder in position for treatment. Front view.

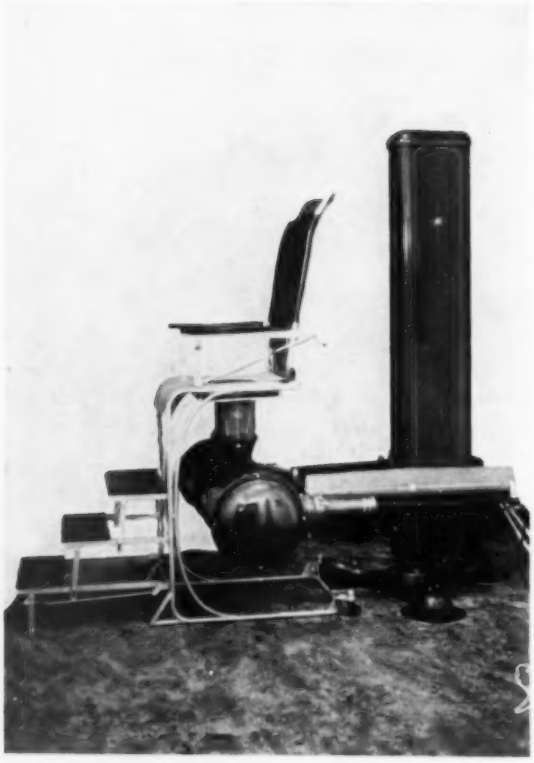

Fig. 2. Chair with steps down and with tube holder in position for treatment. Side view.

When not in use, these steps fold up between the uprights of the chair where they are held securely by a sliding catch (*T*) which can be released at any time.

The seat (*C*) is made of a solid sheet of aluminum, 5 mm. thick, in the center of which is a slight circular depression; the object of this depression is to prevent the patient from sliding forward out of the intended position. In the center of this circular depression in the metal seat has been cut a round opening, 10½ inches in diameter (*G*). The margins of this opening are shaped so as to receive a round piece of shatter-proof glass, allowing clear vision of the perineum and adjacent parts. A double system of graduated lines, 1 cm. apart, one system at right angle to the other, has been provided in the glass window seat so that the size of opening of the underlying lead diaphragm can be determined at a glance. Immediately beneath the glass window in the seat of the chair is a lead diaphragm (*E* and *F*), the opening or closing of which in both directions is governed by threaded rods (*M* and *N*) extending just beyond the back and one side of the chair; these rods terminate in small wheels with a handle to facilitate the operation of the diaphragm. Over the aluminum part of the seat is thrown a sheet of heavy leaded rubber in which a round opening, corresponding to and coinciding with the glass window, has been cut. This sheet of rubber is fastened to the back of the seat through a number of slits that fit over metal buttons. The purposes of this leaded rubber sheet are: (1) to provide additional protection outside the field of irradiation, beyond the zone already protected by the lead plates of the diaphragm, (2) to provide a less cold surface for the patient to sit on, and (3) to provide a sitting surface which, in conjunction with the glass window, can be readily and effectively cleansed between treatments.

Fig. 3. Chair with steps down and with tube holder and patient in position for treatment. Front view.

The assembly of the back and side arms of the chair incorporates the parallelogram principle, with a threaded diagonal rod (*K* and *L*); this makes it possible to vary the inclination of the back according to the patient and according to the desired angle of incidence of the beam of rays in relation to the patient. Provision also has been made for a wide strip of webbing to pass from behind on each side, around the abdomen to the opposite side, in order to prevent any tendency of the patient to slide forward on the seat of the chair. Owing to central depression of the seat, however, such a tendency should be very slight.

The distance from the floor to the inferior surface of the glass window in the seat of the chair is $40\frac{3}{4}$ inches, and the total height of the chair is 77 inches.

In actual use, the proposed perineal field of irradiation is marked on the skin of the patient with an indelible pencil which has been dipped in warm water. This makes strong lines which can easily be seen from below through the glass window. When the field has been properly centered, the lead diaphragm is adjusted accordingly, and the tube holder, with a cone of the proper size, is moved upward until the distal end of the cone (with reference to the tube) is brought in contact with the inferior surface of the glass window of the chair. Treatment may then be given with entire comfort to the patient, as far as comfort can be assured by position.

Inasmuch as such a chair would have to be moved from one treatment room to another, casters were provided at the rear of the chair which rests on the floor. With the steps folded up, all that is necessary to move the chair is to tip it backward until its weight rests on the casters; it can then be moved about at will.

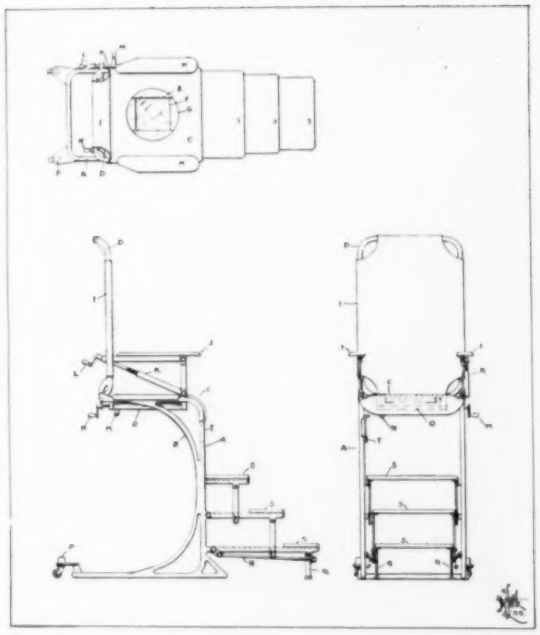

Fig. 4. Diagrams of chair: top, side, and front views.

In order to avoid any discussion of priority, in which I am not in the least interested, I may add that the idea of the chair came to me after I had seen an ordinary metal chair of modernistic design, such as are now quite common. I immediately realized that the absence of back and side supports would make it easy to use in connection with a shock-proof tube holder. No doubt others have had the same idea.

SCIENTIFIC EXHIBIT BY TRANSPARENCIES

A METHOD OF ECONOMY AND UNIFORMITY

By J. A. BEALS, M.D., *Gamble Bros. and Montgomery Clinic*
GREENVILLE, MISSISSIPPI

ORGANIZED exhibits of photographs illustrating clinical and pathological conditions have a well-recognized teaching value for medical schools, clinics and medical society meetings. Such material is usually exhibited in the form of photographic prints on paper or on transparent material such as film or glass. Illustrations that are viewed by transmitted light, transparencies, have an attractiveness, brilliance and accuracy of reproduction which is not possessed, for most observers, by prints on paper.

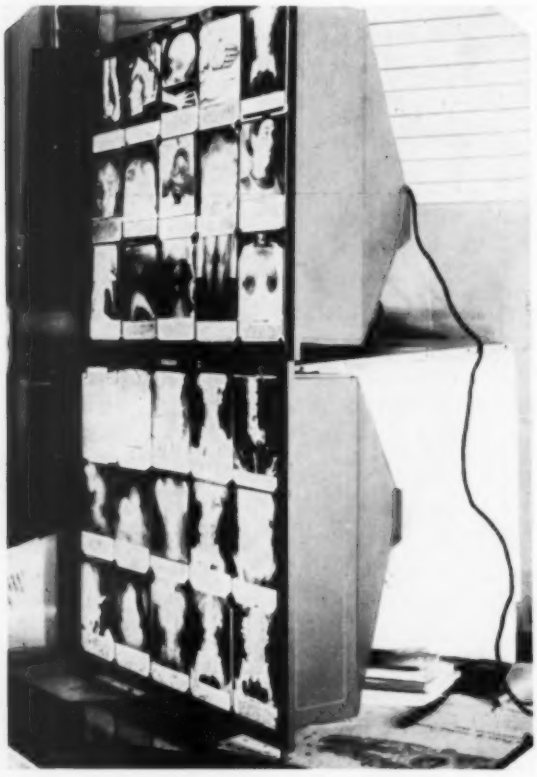

FIG. 1

We have been impressed by the waste of space necessitated by exhibiting a group of illustrations mounted on mats. The question of space sometimes seriously limits the number and inclusiveness of exhibits, as well as the number of exhibitors. Sometimes the lighting is inadequate. Some exhibits display a large series of lantern slides, which economizes space, but this method seems to create a confusion of detail, and reduction of size to a point which sacrifices their value as illustrations.

We have attempted to develop a middle course by making transparencies uniformly on 5″×7″ "process" and "commercial" films. We had made for us, at a reasonable cost, four viewing boxes, each displaying 15 such transparencies. These boxes may be placed side by side or one on another, resting on a table or shelf. Each box is 23″×26½″ in front and is pyramidal behind (Fig. 1). They are larger but designed like ordinary viewboxes for roentgen films. We use a 250 W. "daylight" blue globe Mazda lamp for each box. For illuminating color transparencies a 400 W. clear "floodlight" bulb is superior.

The front of the box is of blue tinted glass to which the transparencies are loosely attached by black lantern slide tape. To keep the films from curling or being brushed off, a plate of good quality window glass is placed in front of this so that the films are between glass. The two glass plates are easily removed from the front of the box when it is desirable to change or rearrange transparencies.

When the boxes are to be transported they may be shipped in the manufacturer's original packing case, or two of them fitted into the back seat of an automobile. The glass plates must be removed and handled with ordinary care to prevent breaking. We repack them in their original shipping case after placing sheets of cotton batting between each glass plate.

The 5″×7″ reduction of most subjects does not seem to sacrifice that degree of

detail which is readily appreciated by most observers. A narrow black margin on the transparency, made by the lantern slide tape, seems to serve the purpose of a mat in separating one picture from those adjacent. The brilliance of transillumination also helps compensate for the reduction in size and close spacing.

We have practiced printing on the bottom of the transparency a legend and short description of the condition. This is done very simply by a double exposure of the film from two negatives, one of the subject, and the other of the legend.

The production of negatives of good quality contributes greatly to the excellence of the transparencies. We can recommend the use of photoflash bulbs, and supersensitive panchromatic film with appropriate filter, for all living subjects. We use the same filter and film, but photoflood bulbs for still subjects. Reductions of roentgenograms are made on commercial film. Photomicrographs are improved by negatives produced on panchromatic films. Transparencies in color are very attractive and can be produced by the Agfa, Lumierè or Finlay processes. Our experience is limited to the latter.

Transparencies not on view in the display boxes are slipped into cardboard stock mounts procurable from dealers in photo supplies. When filed in these mounts a series of related case illustrations can be accumulated and kept readily available.

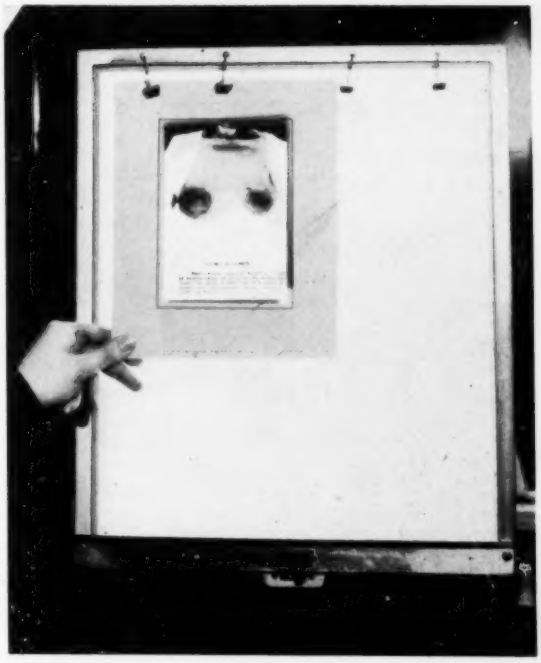

Fig. 2

They are viewed in their mounts before an ordinary roentgen viewing box (Fig. 2). The filed transparencies, as well as the negatives from which they are produced, are a most convenient source from which to make up lantern slides and text illustrations.

The methods described here for exhibiting and preserving case illustrations have appealed to us as economical, efficient and convenient. We trust that others may find useful suggestions from our description.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN AND RADIUM THERAPY

Stewart-Harrison, R. The radiation treatment of actinomycosis. *Brit. J. Radiol.*, Feb., 1934, *7*, 98–110.

Schinz's classification of the various methods of roentgen therapy, as applied to chronic infections, is cited: (1) "disjuncted fractional treatment"—whereby dosages of 200 to 300 r are applied at regular intervals so as to effect a total dosage of about 3,000 r within a period of six months; (2) "simple fractional treatment"—whereby 180 to 200 r are given in daily dosages for a total of 2,500 to 3,000 r within a period of one month; (3) "protracted fractional treatment"—allowing more prolonged daily dosages (because of the use of filtrations up to 1.3 mm. copper and increases of the focal-skin distance up to 60 or 70 cm.) for a total of 3,000 to 4,000 r within one month; (4) "saturation treatment"—whereby maximum radiation is at first applied to full tissue tolerance and thereafter supplementary dosages are added to renew that degree, for a total of about 2,000 r in two weeks, and (5) the "method of decreasing doses"—whereby constantly decreasing daily dosages are given over a period of about two weeks so as to effect a total of 2,500 r. The author has compared the results of the first and third methods of treatment, listed above, on 22 cases of microscopically verified actinomycosis of the head and neck, and he concludes that the protracted fractional treatment is more advantageous. In 8 cases where other organs were involved the disjuncted fractional method was unsuccessful. For these types of cases the protracted fractional method has not been tried but it is hoped that it will be found successful. —*A. A. de Lorimier.*

Fried, B. M. Bronchogenic cancer: treatment with roentgen rays. *Am. J. Cancer*, April, 1934, *20*, 791–806.

Two case reports of bronchogenic carcinoma are detailed. In one, there had been observed, about six years previous to the recent complaints, a mass at the base of the right lung. This had been associated with uncontrollable hiccoughs. The lesion had been considered benign until the development of a persistent non-productive cough and headaches. At this stage, roentgenography revealed a mottled infiltration throughout the right lung and a few scattered densities on the left. Drastic roentgen therapy effected symptomatic relief but the patient died less than a year later—about seven years after the first observations. Postmortem studies revealed a lymphatic spread of a carcinoma which presented the characteristic pattern of bronchial origin. There were dense calcific deposits.

The second case differed in that the pulmonary parenchymal involvement seemed to be limited to the left apex, though there was spread to regional vertebrae and ribs. Though the symptomatology was acute and without suppuration there was a very conspicuous osteoarthropathy of the short long bones. Clinically the patient showed a transverse myelitis and a typical Horner's syndrome. Necropsy showed carcinoma of the left upper lobe with extension into the neck and infiltration of the brachial plexus. The author emphasizes the finding of Horner's syndrome in carcinomatous or tuberculous pulmonary involvement as well as in extrapulmonary tumors of the superior pulmonary sulcus.—*A. A. de Lorimier.*

Sugiura, Kanematsu, and Benedict, Stanley R. The effect of radiation from filtered radon implants on the growth of carcinoma and sarcoma in animals. *Am. J. Cancer*, April, 1934, *20*, 813–826.

Observations were made as to the effect of varied dosages, from single tubes of radon, upon transplants of Flexner-Jobling rat carcinoma and Sugiura rat sarcoma. The dosages were measured in skin erythemas, depending upon the dimensions of the tumors, as outlined by Quimby and Martin. It was found that 2.0 to 3.0 s.e.d. effected complete regression in about 50 per cent of the carcinomas which measured 2 cm. or less in diameter; the same dosage was not effective in 50 per cent of the sarcomas which measured only 0.7 to 1.5 cm. Carcinomas measuring up to 2.0 cm. in diameter showed regression in about 90 per cent of the cases when the dosage was increased

over 3.0 s.e.d., but larger tumors, measuring 2.4 to 3.3 cm. in diameter were seldom destroyed even by dosages up to 6 s.e.d. In the case of the sarcomas, the same dosage was only occasionally effective for tumors measuring 1.5 to 2.3 cm. in diameter.—*A. A. de Lorimier.*

Zuppa, Armando. Roentgenterapia delle glandole surrenali per la cura dell'asma bronchiale essenziale. (Roentgen therapy of the suprarenal glands in the treatment of essential bronchial asthma.) *Arch. di radiol.*, 1933, *9*, 1117–1118.

The author's treatment is based on the theory that essential bronchial asthma is caused by paralysis of the pulmonary sympathetic, allowing the action of the vagus to become predominant. Stimulation of the suprarenals by roentgen irradiation causes increased secretion of adrenalin which acts on the sympathetic and restores normal vagus-sympathetic equilibrium.

He used the following technique: 180 kv., spark gap 38 cm., focus distance 40 cm., filter 9.05 mm. zinc and 3 mm. aluminum, two fields 10×15 cm., dose 100 to 150 r at one treatment, interval between treatments twenty days He irradiated the kidney region as it is practically impossible to irradiate the suprarenals alone. He examined the urine five or six days after each irradiation and never saw any signs of kidney irritation.

He has used the treatment on two men and one woman. The men had both had the disease for many years while the woman had only had it for a year. Immediately after the first treatment all the patients could breathe better. After ten treatments the woman's attacks stopped entirely and have not reappeared in two years. In the men the attacks gradually decreased in intensity and finally stopped for many months.

These preliminary findings have encouraged him to contine the treatment in a larger number of cases and he is now making examinations to see whether there is a real increase of adrenalin in the organism as a result of the irradiation.—*Audrey G. Morgan.*

Lebon: Le Genissel, and Maire. Quelques résultats obtenu par la radiothérapie splénique dans l'urticaire rebelle. (Some results obtained by splenic radiation therapy in rebellious urticaria.) *Bull. et mém. Soc. de radiol. méd. de France*, 1934, *22*, 205–207.

The irradiation of the spleen was attempted in 4 cases of rebellious urticaria with the following technique: lateral field 11×11 cm., 175 kv., 0.2 mm. Cu and 1 mm. Al as filters, 300 to 400 r per seance given twice weekly, the total number of seances amounting to five or six on an average. Three of the 4 cases were completely cured (the fourth case was lost track of), the cure now lasting from eight months to two years.

In conclusion, it is recommended that this method of treatment be attempted as a last resort in chronic cases of urticaria when all other methods have failed. The 3 cases which were followed up are briefly described.—*T. Leucutia.*

Haguenau, J., Gally, L., and Lichtenberg, D. Sur le traitement radiothérapique des algies. (The radiotherapeutic treatment of algias.) *Presse méd.*, 1934, *42*, 531–534.

The authors report very good results with roentgen therapy of penetrating rays in the various forms of essential algias. The technique of irradiation is: 0.04 to 0.05 Å, 200 kv. constant, 1 mm. Cu and 2 mm. Al as filters; 40 cm. skin target distance; total dose of 3,000 r (French) per field of irradiation, through a conical limiting diaphragm 20 cm. at the base, in seances of 500 r twice weekly; repetition of the series within three to four weeks in case of failure. The following are the statistical results: (i) Sciatica. Treated 31 cases; cure in 15 (48.4 per cent); amelioration, 7 (22.5 per cent); failure, 9 (29 per cent). (ii) Cervico-brachial neuralgia. Treated 10 cases. Cure, 6 (60 per cent); amelioration, 2 (20 per cent); failure, 2 (20 per cent). (iii) Neuralgias of face. Treated 21 cases. Cure, 9 (42.8 per cent); amelioration, 4 (19.5 per cent); failure, 8 (38 per cent). (iv) Post-traumatic and postoperative algias. Treated 17 cases. Cure, 5 (29 per cent); amelioration, 4 (22 per cent); 2 slight ameliorations and 6 failures (35 per cent). (v) Talalgia. Treated 5 cases, one single failure. (vi) Coccygodynia. Treated 2 cases, one with cure and one with slight amelioration. (vii) Algias of herpes zoster. (*a*) Early cases: treated 9 cases: cure, 7; amelioration, 1; failure, 1. (*b*) Late cases: no statistics given but method recommended. (viii) Algias during the course of osteites. Four cases of Paget's disease ameliorated.

It is mentioned that all the cures date back longer than two years so that they may be con-

sidered more or less permanent. Because of this success the indications are being gradually extended. The one disadvantage is that it is impossible to tell beforehand which case will respond favorably and which will result in failure. It is recommended that the method be employed in all those instances in which other therapeutic methods have proved unsuccessful. —*T. Leucutia.*

Peyton, William T. Effect of radium on the spinal cord. *Am. J. Cancer*, March, 1934, *20*, 558–572.

Experimental observations were made on the application of radon, intra- and extradurally, after laminectomy on dogs; 1.7 millicuries was found to be the maximum dosage tolerated without the production of paralysis. These studies were applied practically as part of the treatment of a case of myeloma involving a vertebra. This was an especially interesting case in that the early studies revealed only the one lesion. After surgical treatment and the application of radon and subsequent roentgen therapy the patient got around in a very healthy manner. After an interval of almost two years he had recurrence of pains and though Bence-Jones bodies were found in the urine, no lesions could be demonstrated roentgenographically. About three and a half years after the first observation he was found to have generalized skeletal metastases. A second case with multiple involvement at the earliest observations is also reported. The author emphasizes the relief and probable prolongation of life effected by the combination of diffuse and interstitial irradiation in cases where a single lesion is found.—*A. A. de Lorimier.*

Fratini, Carlo. Risultati della roentgenterapie negli elaiomi. (Results of roentgen therapy in oil tumors.) *Radiol. med.*, Feb., 1934, *21*, 158–166.

On the injection of mineral oils such as vaseline and paraffin or of drugs such as camphor in an oil vehicle small nodules may remain which under the influence of stimuli, chiefly mechanical, may develop into connective tissue tumors. The author describes 3 cases in which roentgen therapy of such tumors was very successful and discusses the probable mechanism of action of the rays in such cases.—*Audrey G. Morgan.*

McGregor, Leone. Reactions to radiation in lymph nodes containing carcinoma metastases of the squamous cell type. *Acta radiol.*, 1934, *15*, 129–152.

In 1924 in a study of the effect of roentgen irradiation on pathological tissues Prym came to the conclusion that all changes produced by roentgen rays might also occur spontaneously and that it was impossible to tell histologically whether a piece of tissue had been irradiated or not. The differences between irradiated and non-irradiated tissues were at most only quantitative.

The author removed lymph nodes after irradiation in 41 cases of metastases of squamous cell carcinoma. In 25 of these the lymph nodes were cervical and in 16 inguinal. The primary tumors were on the lip in 16 cases, the tongue in 6, in the mouth in 3, on the vulva in 11, the penis in 2 and the anus in 3. Eighteen non-irradiated cervical and inguinal lymph nodes containing squamous cell carcinoma metastases and 9 irradiated non-carcinomatous cervical and inguinal nodes from cases of squamous cell carcinoma were used as controls.

The fractional method was used both in teleradium and roentgen treatments. Only one of the necessary fields was treated each day and the daily dose was generally $\frac{1}{4}$ or $\frac{1}{3}$ of a skin erythema dose. The total dosage varied with the local and general condition in each case.

The histological changes found in the 41 irradiated lymph nodes were also found, although to a slighter degree, in some of the non-irradiated carcinomatous nodes.

Although two-thirds of the irradiated and only one of the non-irradiated nodes showed degenerative and proliferative vascular lesions in the small arteries, these changes did not seem to be constant predecessors of carcinoma necrosis and did not run parallel with the extent of carcinoma necrosis or with the dose of irradiation. They could not be considered more than a contributory cause of the destruction of the carcinoma. In 11 of the irradiated lymph nodes the carcinoma had evidently been completely destroyed.

The lymphatic tissue did not seem to have suffered any injury from the roentgen or radium irradiation at the time the nodes were resected and it was impossible to decide histologically whether the non-carcinomatous nodes had been irradiated. There were no differences in the histological pictures of the glands irradiated

with radium and those irradiated with roentgen rays.

Plates are given showing the histological pictures and a table showing the details of the results.—*Audrey G. Morgan.*

Meland, Orville N. Treatment of low grade epidermoid carcinoma by means of radium needles. *Calif. & Western Med.*, Dec., 1934, *41*, 390–392.

Thirty-two patients with epidermoid carcinoma of grade I, treated with radium, or by radium in combination with electro-surgery, are the basis of this study. No attempt is made to indicate the permanency of recovery, but rather to show whether these low grade, so-called radioresistant lesions may be successfully treated with radium. Response to surface irradiation was not as favorable as when platinum needles or radon seeds were used. Best results were obtained by using radon seeds or platinum needles containing 1 or 2 mg. of radium, plunged in and around the lesions; in all cases there was a successful primary result. —*W. R. Brooksher.*

Schall, Le Roy A. Carcinoma of the tonsil; a statistical study of 230 cases. *New England J. M.*, Nov. 29, 1934, *211*, 997–1000.

From 1918 to 1934, 230 patients with malignant disease of the tonsil were admitted to the Collis P. Huntington Hospital, an incidence of 1 to 106 in cancer cases admitted. Males comprised 88.7 per cent of the patients, while the age group was that of past middle life, the greatest incidence being in the period 60–65 years. There were but 18 cases with a family history of cancer. The growth was limited to the tonsil in 18 cases only. The lesion was ulcerated in 98 cases and presented tumor in 132. As a first symptom pain was noted in 104, growth in 84, bleeding in 4, hoarseness in 9, ulceration in 4, dysphagia in 14, dysphonia in 10, and leucoplakia in 1. The average duration of these first symptoms was three to six months. Forty-four cases had had prior treatment. Glandular involvement was found early, only 19 showing no evidence of glands. Of the graded cases, there were 38 of epidermoid carcinoma type I; 57 of the type II; 52 of type III, and 7 of the transitional cell carcinoma type; 76 cases were not graded. For the past three years treatment has been by radium and roentgen ray; radium for the local lesion by implantation, and roentgen ray for external irradiation of the neck. In 118 treated cases, no relief was obtained in 43; 23 were relieved without recurrence, and there was recurrence under one year in 47. Of the 23 without recurrence, 5 have died non-cancerous deaths.—*W. R. Brooksher.*

Duffy, J. J. Carcinoma of the tonsil. *N. York State J. M.*, Oct. 15, 1934, *34*, 865–869.

The present study is of 176 cases treated between 1921 and 1930 at Memorial Hospital, New York City. In 46 who did not have cervical nodes throughout their course, 15, or 32.6 per cent, remained free of disease for three or more years. Of the 18 patients who developed neck nodes after admission, 5 remained free of disease for three years or over, a percentage of 27.7.

One of every 10 patients with intraoral cancer admitted to Memorial Hospital in the period 1919–1929 had tonsillar carcinoma. The diagnosis is not always simple and the first symptoms may be no more than would accompany a mild throat infection. More commonly there is a sequence of discomfort, constant irritation, soreness, especially on swallowing, and in advanced cases, pain, referable to neck, ear and head. A neoplasm of the tonsil may progress far in four months. The location, with its profuse blood supply and lymph drainage, causes a rapid growth of the local lesion and early metastasis.

The lesion is not primarily surgical and radiation therapy is routinely employed. The treatment used at different periods is outlined as is that used at the present time. The latter consists in the administration alternately on successive days of 300 to 350 r to the right and left neck until a total of 3,000 to 3,500 r is delivered to each point in twenty days. The factors employed are 200 kv., 30 ma., 60 cm. target skin distance, 1mm. Cu, 2mm. Al filtration, with the usual portal 7.5 cm. Interstitial irradiation is reserved for any residual disease.—*W. R. Brooksher.*

Perussia, Felice. La radioterapia del cancro della bocca. (Radiotherapy of cancer of the mouth.) *Radiol. med.*, Aug., 1934, *21*, 921–955.

Statistical tables are presented which show that in cancers limited to the margin and dorsum of the anterior part of the tongue, the gums and the lower maxillary bone, the results of radiotherapy and surgery are about the same, except that the former are slightly better

because there is no operative mortality. For cancer of the lips, palate and the floor of the mouth the results of radiotherapy are better than those of surgery. For operable cancers of the cheeks, base of the tongue, and tonsils, radiotherapy is distinctly superior. Surgery is decidedly superior for operable metastases of the glands of the neck. The limits of cure have been decidedly increased by radiotherapy, and Pfahler says that 50 to 75 per cent of cases of cancer of the mouth could be cured if the patients could be given thorough radiotherapy in the beginning of the disease. But education of both public and physicians is necessary in order to bring about early diagnosis. When the cases are divided into those with and without gland metastases, the percentage of cures after five years in the cases without gland metastases is 40 per cent, while in the cases with gland metastases it is only 10 per cent. There are, of course, cases that cannot be treated, even with radiotherapy, such, for example, as those with severe sepsis, those with phlegmons such as are seen in advanced carcinomas of the cheek and floor of the mouth, and those in which cachexia is too far advanced.

Biopsy is important as the radiosensitiveness of the different types of cancer of the mouth varies greatly. Surgery is to be preferred in small cylindromata of the palate, in carcinomata with very highly differentiated cells, and slow development, made up chiefly of corneal pearls and adenocarcinoma. Radiotherapy is to be preferred for lympho-epithelioma and for carcinomata with less highly differentiated cells and with numerous and atypical mitoses. The lymphosarcomata and small round cell sarcomata frequently seen in the tonsils, should also be treated by radiotherapy. The technique of radiotherapy also depends on the varying radiosensitiveness of the different types of tumor.

As the majority of cases of cancer of the mouth are prickle cell epitheliomata which are very resistant to radiotherapy, divided doses of rays of short wave length strongly filtered should be given, the dose being as large as possible without injury to the normal tissues. While it is impossible to give a uniform carcinoma dose, as a rule, the dose recommended by Coutard of 3,500 to 4,500 r may be given for mucous membrane and skin epitheliomata. In the case of very sensitive tumors, such as sarcoma of the tonsil, it is not necessary to use Coutard's technique as good results can be obtained with ordinary deep roentgen therapy. Treatment with a single massive dose of roentgen rays is now rarely used in cancer of the mouth, except in very small carcinomata of the lip. The dose of radium is about 1 to 2 mcd given by intratumoral fixation of needles. The combination of external roentgen therapy and intratumoral radium therapy has proved very effective in many cases. Radionecrosis is unavoidable in some cases. Among 375 cases treated by radium from 1928 to 1933 there were 23 cases of radionecrosis. It is seen particularly after the intratumoral use of radium and in patients whose mouths are in bad condition, indicating that it may be caused by infection. It can be reduced to a minimum by a careful technique and hygiene of the mouth. —*Audrey G. Morgan.*

D'Emidio, Angelo Santoro. La radiumterapia nel cancro delle tonsille palatine e dei pilastri. (Radium therapy in cancer of the palatine tonsils and the pillars of the fauces.) *Arch. di radiol.*, 1934, *10*, 208–224.

The author discusses Berven's method of treating these cancers by the external application of radium with which that author has had very good results. But he believes that the best results can only be obtained by a combination of external irradiation and fixation of radium inside the tumors. He uses a small amount of radium, about 5 tubes, sometimes as many as 7, containing 2 mg. radium each. They are fixed in tubes inside the tumor at a distance of about 1.5 cm. from each other and left in place about eleven days until there is quite an intense reaction, with edema and formation of whitish plaques and with more or less intense pain. The tubes are fixed in position with silver wires. They should be buried 5 or 6 mm. beneath the surface. The dose is about 20 to 25 mcd. If this dosage is insufficient the treatment can be repeated. This is associated with external treatment of the whole lymphatic region involved. If the glands are not enlarged the radium is placed at a distance of 1.5 cm. from the skin and applied for ten to twelve days; if they are visibly enlarged the distance is 3 cm. and the time twenty to twenty-five days.

He has had remarkably good results with this method.—*Audrey G. Morgan.*

Matteucci, Eugenio. Sulla roentgenterapia della meningite tubercolare. (Roentgen therapy of tuberculous meningitis.) *Radiol. med.*, Aug., 1934, *21*, 917–921.

Two years ago Bokay of the pediatric clinic of Debreczen reported successful treatment of tuberculous meningitis with roentgen therapy. The author tried the method in 2 cases, following the technique of Bokay exactly: three fields, a right and left parietal and an occipital, irradiated one field a day on successive days; 162 kv., 4 ma., filter 0.25 mm. zinc and 2–3 mm. aluminum, focus-skin distance 34 cm., dose 150–200 r. The patients continued to grow worse in spite of the treatment and both died. He believes, therefore, that Bokay was mistaken in assuming that the patient with tuberculous meningitis dies of the local intracranial lesions and not of the general disease. The tuberculous meningitis is only an episode in the generalized miliary tuberculosis and it is impossible for irradiation to cure the general disease. At most, it could only be useful in beginning and strictly localized cases.—*Audrey G. Morgan.*

Buisson, Mario. Alcune osservazioni sulle cause di recidiva della sicosi volgare del labbro superiore sottoposta al trattamento röntgen. (Causes of recurrence of sycosis vulgaris of the upper lip after roentgen treatment.) *Radiol. med.*, Sept., 1934, *21*, 1054–1063.

The usual causes of recurrence of staphylococcus sycosis of the upper lip are the following: intranasal foci that have not been treated; insufficient duration of the epilation; insufficient treatment so that all the follicles are not disinfected.

The author advocates irradiation of the face, generally total, with sufficient doses to bring about epilation of the diseased areas for at least six months. He gives a dose of 400–450 r on each field with 130–140 kv., filter 2 mm. Al. This dose is repeated after forty or fifty days so as to completely sterilize all the foci. The vestibules of the nasal fossae are irradiated, an illustration being given of the position of the patient for this treatment. If there are any foci of chronic rhinitis they are referred to an otorhinolaryngologist for treatment. This treatment is followed by intense and long-continued treatment with hot compresses with the object of completely sterilizing the follicles and activating nutritive exchange of the tissues to overcome any possible injurious effects of the irradiation.

Photographs are given of patients cured by this method.—*Audrey G. Morgan.*

Buisson, Mario. L'associazione della röntgentherapia e della termoterapia umida nel trattamento del lupus volgare. (Combination of roentgen therapy and moist heat therapy in lupus vulgaris.) *Radiol. med.*, July, 1934, *21*, 786–792.

The Finsen light is generally considered superior to roentgen therapy in the treatment of lupus vulgaris. This may be true when roentgen therapy is used alone, but the author has found a great improvement in the results by using a combination of roentgen therapy and moist heat. Two things are necessary in the treatment of lupus: destruction of the diseased tissue and repair of the loss of substance. Roentgen rays accomplish only the first of these objects. After roentgen therapy alone, repair is slow and there is apt to be secondary infection. The moist heat hastens repair and prevents such secondary infections.

In the roentgen part of the treatment the author gives the maximum dose that can be given without injury to the normal tissues, about 600 to 650 r; another dose of 500 r can be given after about forty days to three months. Hard rays are used, about 180 to 200 kv. with a filter of 0.50 to 0.70 copper and 1 mm. aluminum, to protect the normal tissue and vessels as far as possible, since normal activity of the vessels is required for repair and cicatrization. This is followed by treatment with hot compresses to bring about active hyperemia of the irradiated region. Very hot compresses are applied to the irradiated region and renewed every two or three minutes, to keep up the high temperature, for four hours a day, two in the morning and two in the afternoon. The moist heat treatment is given for from a minimum of 400 hours to a maximum of 800 hours. It results in smooth, soft scars without any tendency to retraction. Colored plates are given showing the excellent results of this method.—*Audrey G. Morgan.*

Ferretti, Luigi. Rilievi sulla roentgenterapia del morbo di Flaiani-Basedow. (Roentgen therapy of Basedow's disease.) *Arch. di radiol.*, 1934, *10*, 50–71.

Twelve cases of Basedow's disease are described in which the author used roentgen treatment. He used two lateral fields with a limitator of 6×8 cm. or in some cases 8×10 cm., 170 kv., 2 ma., focus-skin distance 31 cm., filter 0.2 mm. copper and 2 mm. aluminum. The dose at each treatment was, as a rule, 20 per cent of a skin

erythema dose, though in some cases in which the symptoms were very intense only 15 per cent was used until improvement had begun, when the dose was increased to 20 per cent. The dosage was always measured and controlled with Hammer's dosimeter. One field was irradiated every fifteen days and during the intervals the patients were kept under close observation. After five irradiations per field, making a total of a skin erythema dose, treatment was stopped for forty days and then another series given; if necessary, a third series was given after forty or fifty more days.

There was an exacerbation of the nervous symptoms after the first irradiation but in the further course of the treatment there was a great improvement in the nervous and cardiac symptoms and the general condition. Tremor persisted to a certain extent and the exophthalmos was not greatly improved. The goiters were reduced in size but rarely disappeared entirely. The results were so good, however, that the author thinks the treatment is to be recommended. It is contraindicated in very few cases and there is no danger of any bad effects if the correct technique is used. There are no immediate or late complications except a slight pigmentation of the neck, which generally disappears in time.—*Audrey G. Morgan.*

Overholt, R. H., and Eckerson, E. B. The treatment of cancer of the breast and the results of operation. *New England J. M.*, Oct. 18, 1934, *211*, 703–708.

The early diagnosis of cancer of the breast is fully discussed. Palpable axillary nodes do not necessarily carry a grave prognosis as these may be of inflammatory origin. Intraductal hyperplasia in the chronic cystic breast is considered a precancerous lesion. The diagnostic responsibility for the differentiation of benign tumors, cysts and early malignant lesions is the pathologist's, not the clinician's, since any palpable lump in the breast should be removed for histological examination. Statistics of 719 patients with breast lesions were followed with a percentage of 97.7 per cent; 280 of these were not operated upon; 238 were found to have benign lesions at operation, the most frequent being chronic cystic mastitis. Malignant lesions were found in 201 cases, or 27 per cent of the total cases seeking advice on breast lesions. Of these, 17 were inoperable and 15 refused treatment. All the remaining 169 cases except 4 were followed, these 4 being counted as dead in the statistics. Four cases are not included in whom the pathological diagnosis was not verified. The radical operation was done in 134 cases. Primary mortality was 4, or 2.4 per cent. At the ten-year period, 89, or 54 per cent of these patients were living, 20 with metastasis and 60 without metastasis; 46, or 60 per cent, died within two years. Dead from the disease were 56 and from other causes, 20. Five-year reports on 62 patients are also summarized. The value of deep roentgen treatment and radium implantations as an adjunct in the treatment of breast malignancy is unquestioned. Intensive deep roentgen therapy has been given postoperatively in all cases for the past eight years and, more recently, radium implantation interstitially has been employed in inoperable lesions. In the follow-up, roentgenograms of the chest and long bones are made at varying intervals during the check-up period. Metastases are heavily irradiated. In women operated upon before the menopause, roentgen treatments are directed to the ovaries to produce an artificial menopause and thereby check the stimulation of breast tissue from ovarian hormones. Solitary recurrences have been widely excised as well as treated by the roentgen ray. In 2 patients recurrences were kept under control for over five years after their development. —*W. R. Brooksher.*

Lenz, M., Frantz, V. K., and Kasabach, H. H. Prophylactic roentgenotherapy for carcinoma of the breast. *N. York State J. M.*, Oct. 15, 1934, *34*, 881–887.

The difficulties attending a statistical study of prophylactic roentgen therapy following mastectomy for carcinoma of the breast are discussed, as are the difficulties in the application of the method. Small doses (300 r) at bimonthly intervals have been generally employed. Such repeated small voltage treatments were administered to a series of 78 radical mastectomies from 1923 to 1929 and followed up for a minimum of five years. The technique consisted in the administration of 400 r over the operative chest wall and anterior surfaces of the adjoining axilla and supraclavicular regions, as well as the opposite axilla. All treatments were begun within six months after the operation. The factors were: 130 kv., 0.25 mm. Cu, plus 1 mm. Al filtration and 40 cm. target skin distance. The series was repeated at least once in four to eight weeks. In some cases additional cycles of treatment were given at two-

or three-month intervals several times more. All cases were microscopically proved.

Axillary metastases were absent in only 12 cases and of 12 cases with axillary metastases arising potoperatively, only 1 occurred on the operated side, while 11 occurred on the opposite side, both sides having been irradiated similarly. Thus, axillary metastases appeared mainly where the nodes had not been removed and irradiation did not prevent their occurrence. The postoperative occurrence of supraclavicular metastases corroborates this finding. With a thorough axillary dissection, irradiation of the operated axilla is not necessary, but larger doses are needed for the supraclavicular region on the operated side and over the opposite axilla. Postoperative metastasis to the opposite axilla occurred most frequently with a primary tumor arising in the lower quadrants. In the supraclavicular areas, no metastasis occurred from this field, but in 35 per cent of the tumors arising in the central portion, 36 per cent of those in the upper outer quadrant and 46 per cent of those in the upper inner quadrant, there were metastases.

Fifteen cases were alive and well for more five years after radical mastectomy. Though free from cancer, 1 of the 15 died from pneumonia nine years postoperatively and another from pulmonary tuberculosis fifteen years later. Most deaths occurred during the first three years and survival was greatly influenced by the extent of axillary involvement. The fewest five-year survivals were found in cases in which the primary tumor arose in the central portion of the breast.

In a further study 11 cases clinically diagnosed as carcinoma of the breast were subjected to varying doses of intensive fractional roentgen therapy and mastectomy was performed three to seventy days later, with histological study of the specimens. Analysis of these cases makes it questionable whether sufficient dosage for permanent arrest of hidden cancer cells can be administered without serious damage to the normal tissues in the operative area. Apparently viable cancer cells were found in all these tumors on microscopical examination, and mitoses were seen in 6.

The real function of postoperative roentgen therapy should be to increase the tendency of the body to restrain the growth of cancer cells left behind after operation and for this high voltage roentgen therapy is probably preferable. —*W. R. Brooksher.*

Baird, Berry C., Lingley, J. R., and Palmer, R. S. The failure of roentgen-ray therapy of pituitary and adrenals in essential hypertension. *New England J. M.*, Nov. 22, 1934, *211*, 952–953.

Eight patients with severe essential hypertension in the late stages of the disease were treated by conservative roentgen therapy over pituitary and adrenals or both. A careful follow-up over two years shows no favorable effect on blood pressure or symptoms. The usual dosage was 600 r to the pituitary from two fields, 300 r to each field, and similarly to the posterior adrenal areas.—*W. R. Brooksher.*

Boyd, Montague L. Cancer of the bladder. *J. Med. Ass. Georgia*, Oct, 1934, *23*, 378–382.

The author's minimum standard for treatment is: (1) deep roentgen therapy to all patients in repeated courses, regardless of the radiosensitivity of the growth; (2) transurethral treatment of all smaller growths of the less malignant type by electrocoagulation and the implantation of radon in and about the tumor; (3) suprapubic cystotomy for treatment if the transurethral route is not available or adequate; (4) radical resection of the bladder when possible for growths which do not show evidence of being radiosensitive, provided metastases cannot be demonstrated and there is reason to believe the patient will live ten years or longer if a local cure is obtained; (5) cystectomy, preceded by nephrostomy, should be selected for patients having extensive involvement of the bladder with the growth more or less limited to the bladder, provided there is hope of obtaining a cure, and (6) double nephrostomy, or nephrectomy on one side and nephrostomy on the other, for patients with extensive, intractable, painful carcinoma where diversion of the urine offers hope of giving the patient relief even for a few months.

The maximum effect of irradiation can only be obtained by radon implantation. Radium should be used not only in the definitely malignant growth, but also in tumors of doubtful malignancy. Radical resection of the bladder has afforded the best outcome of any of the measures developed for treatment.—*W. R. Brooksher.*

Kahn, Milton E., and Norris, Samuel. Primary carcinomas of the fallopian tubes. *Am. J. Obst. & Gynec.*, Sept., 1934, *28*, 393–401.

Four additional cases of primary carcinoma

of the fallopian tubes are added to the 270 now recorded. The clinical diagnosis is extremely difficult and even at operation the lesion is often unrecognized. Opening of all tubes at the time of operation with an inspection for papillary growths would materially aid at times in the diagnosis and in the institution of proper treatment. A negative curettage with a history of irregular bleeding, or a brownish or bloody discharge in a woman over forty, is suggestive of tubal carcinoma. In such cases the adnexa should be carefully palpated for enlargements. —*W. R. Brooksher.*

Schmitz, Henry, and Benjamin, E. L. The early histologic diagnosis of carcinoma of the uterine cervix. *J. Am. M. Ass.*, Sept. 15, 1934, *103*, 808–809.

Early detection of carcinomas of the cervix is only possible by including palpation and inspection of the genital organs in every physical examination. Chronic cervicitis may be cured by linear cauterization of the vaginal portion of the cervix. Should the lesion recur or fail to heal, low circular amputation of the diseased part of the portio vaginalis and serial microscopic study of the tissues will lead to an early diagnosis of malignancy.—*W. R. Brooksher.*

Bermond, Marco. Sulla roentgenterapia del carcinoma della prostate. (Roentgen therapy of carcinoma of the prostate.) *Radiol. med.*, Aug., 1934, *21*, 955–974.

The author describes 8 cases of carcinoma of the prostate treated by roentgen therapy since the beginning of 1930. He emphasizes the superiority of roentgen therapy to surgical and medical treatment in these cases. Local clinical cure without recurrence was brought about in all his cases, though 3 of them presented bone metastases. The palliative results were excellent. The greatest danger is that of metastases which may occur soon after the treatment or after several years. Roentgen therapy does not apparently overcome the tendency to metastases in cancer of the prostate. For that reason the author advises combined roentgen and surgical treatment in advanced cases. He gives roentgen treatment with a single large dose, followed three months later by prostatectomy and after another three months by another irradiation of the same kind as the first. Fifty per cent of his patients are still living three years after irradiation.

He advocates brief intensive irradiation, giving 2,600 to 3,000 r in four hours over four fields. He believes that fractional methods of irradiation are not to be advised because fractioning decreases the efficacy of the irradiation and also increases the radioresistance of the cancer cells. Many authors believe that cancer of the prostate is refractory to roentgen irradiation, but this is true only in a relative sense, and only when the wrong technique is used.—*Audrey G. Morgan.*

Gütig, Karl. Zur Nachbehandlung des exstirpierten Röntgenkarzinoms. (After treatment of extirpated roentgen carcinoma.) *Strahlentherapie*, 1933, *47*, 390–392.

A roentgen department was established in a hospital at Witkowitz in 1898. When the author took charge of it twenty-four years ago three of the personnel had already suffered severe chronic roentgen injuries of the skin caused by the action of unfiltered rays on the hands. All three showed severe ulcerative hyperkeratoses on the backs of the hands and the nails and nail beds showed the characteristic changes. The physician died of intercurrent disease in 1931, more than thirty years after the burn without carcinoma developing. The nurse had to have one finger extirpated for carcinoma six years ago. The attendant, who has been working as a surgical attendant for the past ten years and has not been subjected to the action of roentgen rays, had to have his left middle finger removed in 1919 for carcinoma and in 1926 a part of the right ring finger. At the beginning of this year a large ulcer developed on the back of his hand. Histological examination of excised tissue showed carcinoma. The wound healed poorly after extirpation of the ulcer, and the author used 10 per cent boric-suprarenin salve, with astonishingly good results. The wound healed in a short time and is still healed after three months.

A remarkable point about these cases is that there was no metastasis in spite of repeated operations for carcinoma and the fact that the injuries dated back thirty-three years. It is possible that the withdrawal from exposure to roentgen rays had something to do with this favorable outcome. Most of the physicians who have died from metastatic roentgen carcinoma have worked with rays up until shortly before death.—*Audrey G. Morgan.*

von Albertini, A. Microcytenbefunde in Rundzellensarkomen als histologischer Ausdruck ihrer Strahlensensibilität. (The dem-

onstration of microcytes in round cell sarcomas as a histological manifestation of their radiosensitiveness.) *Acta radiol.*, 1934, *15*, 331–349.

The author emphasizes the importance of histological diagnosis in the treatment of malignant tumors. He describes 3 cases in which the histological picture of excised specimens showed the great radiosensitiveness of the tumors. All of these were round cell sarcomas with cells of medium size characterized by a delicate structure of the tumor cells, and particularly by the presence of so-called microcytes, some of them scattered and others grouped in foci. These are a characteristic degenerative form of tumor cell, which in many respects show a close morphological resemblance to erythroblasts. They are generally small cells with a peculiarly shaped pyknotic nucleus, very much like that of the microcytes in lymphatic tissue. These tumors were not lymphosarcomas, however. The presence of these microcytes is an indication of spontaneous degeneration or a tendency to spontaneous degeneration, and therefore an indication of radiosensitiveness. As a matter of fact, all three of these tumors proved to be very radiosensitive. The author believes, therefore, that the finding of microcytes in sarcomas is an indication of radiosensitiveness.—*Audrey G. Morgan.*

Gilbert, R., Babaïantz, L., and Kadrnka, S. L'influence de la roentgenthérapie sur l'évolution de la granulomatose maligne. (The effect of roentgen therapy on malignant granulomatosis.) *Acta radiol.*, 1934, *15*, 508–522.

The authors discuss 60 cases of malignant granulomatosis observed between 1920 and 1933. They make a special study of the effect of irradiation on these cases. There are four types of cases, an acute type in which roentgen therapy has no effect, a rapid type in which very good improvements can be brought about but they are transitory, a moderate type which represents more than half the cases in which roentgen therapy prolongs life, sometimes for long periods, and restores the patients to apparent health, and frequently to complete capacity for work. There is also a slow type which includes more than a fifth of the cases, in which roentgen therapy gives such long and perfect remissions that in some cases they may be considered cures. Roentgen therapy, therefore, is effective in 78.4 per cent of the cases. A prognosis should never be made in this disease before roentgen therapy has been tried.—*Audrey G. Morgan.*

Zuppinger, Adolf, and Rohrer, Carl. Zur Klinik und Therapie der Struma maligna Bericht über 101 Fälle von 1918-1933. (Report of 101 cases of malignant struma treated from 1918 to 1933.) *Acta radiol.*, 1934, *15*, 523–538.

A report is given of 101 cases of malignant struma treated in the course of the past fifteen years at the Roentgen Institute of the University of Zurich. The name malignant struma is applied to a number of different forms of malignant tumor which originate from different tissues of the thyroid. The histology of these tumors varies greatly, but the clinical picture is quite uniform. These malignant tumors generally develop in thyroids that have already undergone goiterous changes. Sarcomata are said to run a more rapid course than carcinomata. If malignant goiter is not treated it generally causes death within a year. The prognosis is very bad.

Among the authors' cases only 6 could be operated upon radically, and only 3 of these have remained free of symptoms since. Complete roentgen treatment could be carried out in only 48 cases. In all the others only palliative treatment could be given. A comparison of the different methods used shows that operation followed by irradiation did not give any better results than irradiation alone, though the material of the irradiated cases was in a more advanced stage than that of the operative cases. Treatment with fractional doses over a long period gave considerably better results than the method used in the beginning, and freedom from symptoms was obtained in some very advanced cases. The time is not yet long enough to say whether the patients are permanently cured or not. The various statistics found in the literature in regard to the results of treatment in malignant tumor cannot very well be compared as the differences in the material are too great.—*Audrey G. Morgan.*

Schmitz, Henry. Treatment of uterine hemorrhages due to benign lesions with radium and roentgen rays. *Am. J. Obst. & Gynec.*, Sept., 1934, *28*, 355–363.

The author analyzes 586 benign lesions treated medically, surgically and radiologically, and an additional 433 cases of benign uterine

hemorrhage that had definite indications for radiation therapy. The diagnosis should without exception include a thorough history, a detailed bimanual examination, and a curettage or biopsy. In the treatment of bleeding myomatous uteri surgery or radiology may be employed. Irradiation is indicated: (1) in a bleeding intramural myoma free from adnexal complications, degeneration or malignancy, and located intramurally, in a patient thirty-six years or older; (2) in women younger than thirty-six years who are poor surgical risks due to constitutional complications, and (3) radium may be used in uteri not larger than a first trimester pregnancy, and roentgen rays in myomas of all sizes. Invariably complete amenorrhea ensues after 1,800 mg-el-hr. of radium therapy. With roentgen rays 450 r should be administered through two fields at the seat of the ovaries. Good end-results from irradiation were obtained in 90.14 per cent of myomata uteri. In the bleeding uteri, the good results were 98.66 per cent. Radiation therapy is the method of choice in well-selected, uncomplicated cases of uterine hemorrhage, due to benign causes.—*W. R. Brooksher.*

Faust, J. J. Radiation therapy of gas bacillus infection. *Illinois J. M.*, Dec., 1934, *66*, 547–550.

Report is made of the successful treatment of 4 out of 5 cases of gas bacillus infection by combined serum and radiation therapy. Roentgen treatment consisted in the administration of 45 r to each infected area, using a portable unit. —*W. R. Brooksher.*

MISCELLANEOUS

Schlathölter, Herbert. Abnormer Haarwuchs als Folge röntgendiagnostischer Untersuchung. (Abnormal growth of hair after roentgen examination for diagnosis.) *Strahlentherapie*, 1933, *47*, 393–395.

A case is described in a patient who at the age of sixteen had been injured by having a chest fall on his head. Afterward he was obliged to hold his head in an oblique position, and could not hold it up straight. An attempt was made to take a lateral roentgenogram of the cervical vertebra. The tube was placed so near to his left shoulder that several sparks touched his arm. Afterward he was examined 17 or 18 times. About eight days later vesicles apeared on the skin, accompanied by itching. This was followed by brownish discoloration of the skin and a gradual growth of long hair over the irradiated region within the next few years. It reached its maximum growth four years after the irradiation. The author does not know of any other case in which roentgen irradiation resulted in a growth of hair on a part of the body not normally covered with hair.—*Audrey G. Morgan.*

Ellinger, F. Untersuchungen über die Hautwirkungen von Röntgenstrahlen am Kaninchen. II. Mitteilung. Weitere Untersuchungen über die Wirkung mittelharter Strahlung am Kaninchenohr. (Some studies of the effects of roentgen rays on the skin of rabbits. II. Further investigations of the effects of moderately hard rays on the rabbit's ear.) *Strahlentherapie*, 1933, *47*, 517.

On the basis of the experimental results detailed in this paper Ellinger divides the reactions taking place in a rabbit's ear after exposure to medium-hard rays (100 kv., 6 ma., 2 mm. Al filter, HWS = 0.16 mm. Cu) into four stages which correspond in general to those described in man but which do not agree very closely with the usual conception of "erythema and pigmentation" These reactions after correction for errors due to the latent period of stages 2 and 3 are evaluated statistically. It is shown that a dose between 1,500 and 2,000 r produces first an erythema and then epilation. This shows that the rabbit's skin has a tolerance 2.5 times greater than that of human skin. The results of these experiments permit the foundation of an "experimental radiotherapy" (analogous to experimental pharmacology) in that the data from animal experiments can be applied to man after making certain corrections. —*E. T. Leddy.*

Ellinger, F. Untersuchungen über die Hautwirkungen von Röntgenstrahlen am Kaninchen. III. Mitteilung. Die Wirkung einer harten Strahlung und ihre Beeinflussung durch Tonephin. (Some studies of the effects of roentgen rays on the skin of rabbits. III. The effects of a hard radiation as influenced by tonephin.) *Strahlentherapie*, 1933, *47*, 727.

Using the same experimental conditions as before, Ellinger studied the effects of hard roentgen radiation (180 kv., 4 ma., 0.5 mm. Cu and 1 mm. Al filter—HWS = 0.95 mm. Cu) in doses of 150 and 700 r applied to fields 2×3 cm. on the rabbit's ear. Checked up statistically there was found in the case of stage 2 of the reaction

no difference from the results found with moderately hard radiation at 100 kv., 4 ma., and 2 mm. Al filter. Stage 3 (the pigmentation) came on more slowly. The delayed pigmentation is probably due to a lesser absorption of the hard rays. The effect of tonephin (a blood pressure increasing substance from the posterior lobe of the hypophysis) hastens the course of stages 2 and 3. The author emphasizes the value of radiation experiments in the study of pigment production.—*E. T. Leddy.*

Ellinger, F. Untersuchungen über die Hautwirkungen von Röntgenstrahlen am Kaninchen. IV. Mitteilung. Die Bedeutung der Schilddrüse für der Ablauf der Hautreaktionen bei mittelharter Strahlung. (Some studies of the effects of roentgen rays on the skin of rabbits. IV. The importance of the thyroid in determining the course of the skin reaction from medium hard rays.) *Strahlentherapie*, 1933, *48*, 97.

Thyroidectomized rabbits showed a prolonged course of reaction in the ear after an irradiation at 100 kv., 4 ma., 2 mm. Al filter (HWS 0.16 mm. Cu) in doses of 150 and 700 roentgens.—*E. T. Leddy.*

Schubert, M. Das Ionognom, ein geeingnetes Dosierungsgerät für die Oberflächentherapie. (The ionognom, a suitable dosimeter for superficial therapy.) *Strahlentherapie*, 1933, *47*, 733.

Schubert states as a result of his investigagations that the ionognom, because of its handiness, transportability, ruggedness, protection and price, represents the best type of modern dosimeter. Completely automatic during readings and the facts that dose and half-value determinations can be made at the skin with radium control recommend the instrument technically. Checked against the Hammer dosimeter and the Martius ionimeter it showed complete independence of wave length effect with no changes due to the chamber in the superficial therapy range and had a high degree of accuracy.—*E. T. Leddy.*

Uhlmann, E., and Pychlau, H. Über ein neues Messinstrument für die Röntgenoberflächentherapie. (A new measuring device for superficial therapy.) *Strahlentherapie*, 1933, *47*, 738.

The authors have checked up the applicability of the ionognom to dosimetry in superficial therapy. Because of the accuracy (±2 per cent from 50 to 150 kv.), the dependability and convenience of use, it is to be recommended.—*E. T. Leddy.*

Glocker, R. Die physikalischen Grundlagen der Strahlenbiologie. (The physical foundations of radiation biology.) *Strahlentherapie*, 1933, *48*, 1.

Glocker points out the necessity for a correlation of purely physical data with biological ones by means of carefully controlled experiments. Some such studies have been reported by the author in this journal.—*E. T. Leddy.*

Pape, R. Zur Frage des Vergleichs der Hautreaktion unter verschiedenen Bestrahlungsbedingungen. (The comparison of the reactions of the skin produced under different conditions of irradiation.) *Strahlentherapie*, 1933, *48*, 73.

In estimating different biological effects produced by different radiation techniques, it is fundamental to know whether the skin was or was not loaded to the same degree. Aside from differences in sensitivity the reaction of skin depends on four factors: (1) the total dose D, (2) the r-dose per minute I, (3) the total duration of treatment T, and (4) number of fractional doses N. Pape attempted to evaluate the factors IT and N quantitatively by means of a compensating technique. N was limited first of all to a comparison of continuous with halved exposures. On the same patient the reactions of two symmetrically placed fields were compared with each other; one of these treated under fixed conditions served as a normal, while in the second field the conditions were changed in such a way that one of the factors tended to increase the reaction while the other decreased it. The conditions were then determined under which the effect of the factors balanced each other so that the reaction in the fields of exposure was identical. For the comparison of continual with halved irradiation with the same total dose with variations in the minute-r-afflux to a ratio of 1:5 (from 6 r/min. to 30 r/min.) the reactions were the same if the total time of irradiation was held at the same ratio as the minute r-afflux. The limits of the sources of error in this reaction equivalence rule are discussed. For practical purposes the important point is that it permits a comparison of halved irradiations with different r intensities per minute with each other and on the basis of the formula

$$X=\sqrt{\frac{I_2,\ T_2}{D\ (=2d_2)}}$$

One can make adjustments to produce an identical reaction when using divided irradiations with the same total dose.—*E. T. Leddy.*

Wolf, P. M., and Riehl, N. Über neuartige Emanationsprepärate für Bestrahlungs-Zweeke. (New radon applicators.) *Strahlentherapie*, 1933, *48*, 165.

The authors describe special applicators useful where adjacent fields are to be irradiated in those cases where telecurietherapy is economically impossible, and in this applicator they use concentrated radon which they obtain from their device, the radonator, which utilizes small quantities of radium.—*E. T. Leddy.*

Jüngling, O., and Langendorff, H. Biologische Ausdosierung von Radiumpräparaten. (The biological dosage of radium preparations.) *Strahlentherapie*, 1933, *48*, 174.

The authors used ova of *Drosophila melanogaster* as test object. They found the half-value dose (Halbwertdosis) for all roentgen wave lengths investigated to be 195 r, in agreement with the figures of Packard. These eggs were exposed to radium applicators of varying shapes and concentrations. Some very interesting results were obtained which cannot be abstracted. Consultation of the original paper is earnestly advised to those interested.—*E. T. Leddy.*

Herzog, G. Ein direktzeigendes Radiumdosimeter mit Wechselstromnetzanschlussgerät. (A direct reading radium dosimeter which can be connected directly to alternating current.) *Strahlentherapie*, 1933, *48*, 187.

This device illustrated by diagram and photograph can be hooked up directly to the lighting circuit and reads off on the scale the value of the radium preparation under examination directly in milligrams.—*E. T. Leddy.*

Santholzer, W. Versuch zur Lösung der Frage der Permeabilität der Haut für Radiumemanation. (Some studies on the permeability of the skin to radium emanation.) *Strahlentherapie*, 1933, 48, 519.

The question of the permeability of the skin for radon is important especially in the evaluation of radium baths. By a simple procedure Santholzer found that depending on the radioactivity of the water from 1.1 to 1.4 per cent radon gets into the blood. Permeability decreases in a linear manner with time and is defined by the formula K_1-K_2t in which K_1 and K_2 are constants.—*E. T. Leddy.*

Meldolesi, Gastone, and Coari, Luigi. L'ossido di torio come mezzo di contrasto in radiodiagnostica per lo studio delle vie linfatice. (Thorium oxide as a contrast medium in roentgen study of the lymphatic tracts.) *Radiol. med.*, May, 1934, *21*, 522–540.

The authors describe experiments in rabbits and dogs in which they injected 25 per cent colloidal thorium oxide for the purpose of demonstrating the lymphatic tracts. The amounts injected were in proportion to the size of the animals. The protocols of the experiments are given and illustrated with roentgenograms showing the course of the lymphatics.

They found that when thorium is injected into the body cavities or even into the subcutaneous tissues or muscles, it is eliminated through the lymphatics, making them visible on roentgen examination. The passage of thorium from the abdomen to the thorax and to the retrosternal glands and those of the neck was shown very clearly. The outlines of the various organs were shown distinctly. On injection into one pleural cavity the contrast liquid passed into the other and the pericardium was outlined and this was probably due to passage through the lymphatics, but this is not absolutely certain as in dogs there is an opening between the two pleural cavities and in rabbits the thorax is so small that some of the liquid might have been injected into the opposite side. At any rate the passage from the thorax to the peritoneal cavity is not nearly so clear as that in the opposite direction. Passage from the thorax to the peribronchial glands was seen in only a few cases but the retrosternal glands were almost constantly visible; they could be differentiated from the retrobronchial glands only in the lateral projection.

Histological examination showed that the thorium was caught and retained in special cells called thorium cells. These cells probably represent a specific reaction of the tissues to the thorium. They were unable to see true phagocytosis on the part of the mesenchymal cells and those lining the serous cavities such as that reported by other authors.

Attempts were made to apply this method in man but they were not very successful as the lymphatics could not be demonstrated clearly without injecting amounts of thorium that

were injurious to the tissues.—*Audrey G. Morgan.*

Ponzio, Mario, and Sinistrero, Cesare. L'archivio radiografico. (Roentgen filing system.) *Radiol. med.*, Sept., 1934, *21*, 1064–1074.

This is a detailed description of the filing system for roentgenograms in use at the Mauriziano Roentgen Institute in Turin, with illustrations of the filing cabinets and cards and a description of the classification in use. The plates are filed according to size and the filing cards so classified that the roentgenograms for any given patient or any given condition can be found easily and quickly.—*Audrey G. Morgan.*

Gallavresi, Luigi. Fondamenti generali della radiografia. (General principles of roentgenography.) *Radiol. med.*, June, 1934, *21*, 689–710.

This is a very technical discussion of the mechanism of production of the roentgen image.—*Audrey G. Morgan.*

Niggli, P. and Brandenberger, E. Die Bedeutung röntgenographischer Kristallstrukturuntersuchungen für die Medizin. (The importance of roentgen examination of the structure of crystals in medicine.) *Acta radiol.*, 1934, *15*, 350–363.

This is a technical discussion of the method of roentgen examination of the structure of crystals of submicroscopic size. The authors point out the importance it may have in medicine in the study of the structure of minerals, and of the bones, and in establishing general laws in regard to the structure of crystalline matter. The method should be used in association with other methods, particularly microscopic, microchemical and roentgen spectroscopic.—*Audrey G. Morgan.*

Schinz, H. R., and Peyer, B. Über die Anwendungsmöglichkeiten der Röntgenuntersuchung in der Zoologie. (The possibilities of roentgen examination in zoology.) *Acta radiol.*, 1934, *15*, 380–408.

The authors have made roentgen studies of various species of animals and find, as was to be expected, that the method is useful only when the differences of absorption are great enough, when the parts to be photographed are not too small, and when the results cannot be obtained just as well or better by other means. Contrast media may be used in zoological study also by injection into the body cavities as well as by ingestion. It is advisable to make drawings from the roentgenograms, as it insures a thorough uniform treatment of the whole material, and for purposes of publication gives greater independence of scale. The principal use of the roentgen method in zoology is as a means of discovering new facts and it may also often be recommended as a practical way of presenting the results obtained by direct examination. The roentgenogram combines the two advantages of being diagrammatically clear and true to nature. As the roentgenogram shows the skeleton and the soft parts in their natural relation to each other, it is in many cases a useful supplement to the representation of the skeleton alone.

At present roentgen examination does not seem to be used as fully as it should be. Further work will show in what directions it most usefully supplements other methods of investigation.—*Audrey G. Morgan.*

Peyer, B. Über die Röntgenuntersuchung von Fossilien, hauptsächlich von Vertebratem. (Roentgen examination of fossils, particularly vertebrates.) *Acta radiol.*, 1934, *15*, 364–379.

After a brief review of the more important literature on the subject, the author describes his practical experience in the course of extensive roentgen studies which he has made for many years of the fossil remains of vertebrates in bituminous slates in certain areas in Switzerland. He has compared these with roentgenograms made of fossils found in other regions. All the roentgenograms were made in the Roentgen Institute of the University of Zurich. There is nearly always sufficient difference of absorption between the fossils and the stone in which they are inclosed to give clear pictures. The results depend, to a certain extent, on the thickness of the bone in proportion to that of the stone, but if the stone is too thick it can generally be chiselled down sufficiently to give a good picture. The author discusses the technique used for this method of roentgen examination and gives illustrative roentgenograms.—*Audrey G. Morgan.*

Herzog, G. Neue Erkenntnisse über den Aufbau der Atomkerne. (The structure of the atomic nucleus.) *Acta radiol.*, 1934, *15*, 319–330.

The author describes the way in which the

nuclei of atoms can be disintegrated and atoms of one element artificially transformed into those of another by bombardment with alpha rays and high speed protons. By certain transformations in the nuclei neutrons are produced, which are particles with the unit mass not charged with electricity. Attempts at disintegration by means of cosmic radiation led to the discovery of positrons. The positron has the same mass as an electron, but it is charged with positive electricity. At present positrons can be produced in far greater numbers by artificial nuclear processes without the help of cosmic radiation. In the course of such experiments the author succeeded in demonstrating the existence of new elements with properties similar to those of radioactive substances (artificial radioactivity), which discharged positron spontaneously. In the latter part of the article the author discusses the discovery of heavy hydrogen, diplon, and its chemical composition.—*Audrey G. Morgan.*

Schinz, Hans R. Röntgen und Zürich. (Roentgen's life in Zurich.) *Acta radiol.*, 1934, *15*, 562–575.

This is a brief sketch of Roentgen's life particularly the part of it that was passed in Zurich, with illustrations of the places associated with his life there.—*Audrey G. Morgan.*

Zehnder, L. Persönliche Erinnerungen an Röntgen. (Personal recollections of Roentgen.) *Acta radiol.*, 1934, *15*, 557–561.

The author first met Professor Roentgen in 1886 when on a vacation and they took some mountain-climbing trips together. He later became his assistant and worked with him the rest of his life, helping him in the development of roentgen tubes. He gives a brief sketch of Roentgen's life with incidents relating to their personal association and work together.—*Audrey G. Morgan.*

Lüdin, Max. Knochensarkom nach experimenteller Röntgenbestrahlung. (Bone sarcoma after experimental roentgen irradiation.) *Acta radiol.*, 1934, *15*, 553–556.

Recently reports have been made of the development of sarcoma in regions that have been irradiated for bone tuberculosis. In order to determine whether irradiation does cause bone sarcoma the author irradiated the tibia of adult rabbits. The upper end of the tibia was irradiated with the following technique: 120 kv., 2.5 ma., filter 4 mm. aluminum, half-value layer 0.28 copper, focus skin distance 23 cm., size of the fields 25 sq. cm., dose per treatment 200 r. Within a period of 6½ months 40 irradiations were given at five-day intervals, with a total dosage of 8,000 r. In the course of this time the hair of the animals fell out, a moist dermatitis developed with slowly increasing contracture of the knee joint. Palpation of the irradiated bone was very painful. A tumor developed on the irradiated head of the tibia and slowly increased in size. Microscopic examination showed chondrosarcoma of the head of the tibia.

While these findings cannot be applied directly to man, the author believes that there may be danger of the development of sarcoma in protracted fractional irradiation. He thinks that histological examinations should be made of the bones on autopsy of all patients who have been given protracted fractional irradiation.—*Audrey G. Morgan.*

Leistner, K. Über ein einfaches Ionometer für Strahlenschutzmessungen. (A simple ionometer for radiation protection measurements.) *Strahlentherapie*, 1933, *47*, 551.

Leistner describes and illustrates an instrument of high sensitivity and great accuracy which is applicable to studies of protection, to the determination of scattered radiation, to dosimetry in radiotherapy, for the examination of technical materials or to any other purpose where small amounts of radiation are to be quantitated.—*E. T. Leddy.*

Strauss, S. Die neue Tubuskammer zum Mekapion. (The new cone-chamber for the Mekapion.) *Strahlentherapie*, 1933, *47*, 371.

This new ionization chamber is incorporated into the treatment cone and is connected for dosage determinations to the Mekapion.—*E. T. Leddy.*

Sevin, W. Erfahrungen bei der Dosierung in der Röntgenoberflächentherapie mit besonderer Berückrichtigung des Durometers. (Some experiences in dosimetry in roentgen superficial therapy with special reference to the durometer.) *Strahlentherapie*, 1933, *47*, 364.

Comparative measurements of the HWS with the ionometer (Mekapion) and the durometer gave good agreement in the case of the copper half-value layer. But the values determined by

the durometer for aluminum are 2.0 mm. too low. Comparisons of the r measurements of the Sabouraud tablets and of ionization systems at the voltages and filters commonly used in superficial therapy show a definite variation of the tablet values with hardness. The absolute figures agree only partly with measurements reported by other authors.—*E. T. Leddy.*

Schubert, M. Das Küstner-Universal dosimeter als Messgerät für die Oberflächentherapie. (The Küstner-Universal dosimeter as a measuring device in superficial therapy.) *Strahlentherapie*, 1933, *47*, 359.

Schubert concludes from a study he made of the Küstner apparatus that it is unsuitable for the purposes of superfiical therapy as it has too high an error.—*E. T. Leddy.*

Holthusen, H., and Braun, R. Nochmals zur Frage der Qualitätsmessung. (Some further remarks on quality determinations.) *Strahlentherapie*, 1933, *47*, 263.

The authors show that in the case of technically inhomogeneous roentgen rays (bei unhomogenen technischen Röntgenstrahlen) the various methods of determining the decrease of intensity (the weakening coefficient, percentual absorption, true HWS, reduced HWS) lead to values which differ from each other but which through the method by which they are measured are specific. Technically inhomogeneous radiation cannot be defined by any value of decrease of intensity. It must be defined by the value of the degree of its inhomogeneity. For defining the degree of inhomogeneity the half-value layer value h, the quotient of the second and first HWS or the inhomogeneity factor ω will give the relationship between the average wavelength calculated from the HWS and the shortest wavelength as determined from the maximum voltage. Curves of the decrease of intensity of inhomogeneous radiation mixtures are similar to each other. Measurement of the HWS in connection with the quality diagram at a given peak voltage or with a definite fore-filter gives a determination of the degree of inhomogeneity and by the use of the diagram of the inhomogeneous decrease of intensity curve gives data on the general courses of the decrease of intensity of the radiation. If the average wave length of a radiation is to be given the starting point is the reduced HWS which can be obtained from the true HWS by multiplication by a reduction factor dependent on ω. The hardness of the radiation in the case of the first HWS is obtained by the relationship of the reduced HWS of the radiation after penetration of the HWS (Intensity J/2) and the reduced HWS of the emerging radiation. This relationship of the reduced half value layer stands in direct relationship to the inhomogeneity factor ω.—*E. T. Leddy.*

Lachmann, E., and Stubbe, H. Über die Beziehung von Röntgendosis zer Genmutationsrate bei verschiedenen Strahlenqualitäten. (The relationship between the roentgen dose and the rate of gene mutation with different radiation qualities.) *Strahlentherapie*, 1933, *47*, 65.

The authors exposed Antirrhinum magnus L. to 6 geometrically progressing doses of radiation ranging from Grenz rays to 175 kv. They could show no qualitative or quantitative changes in mutability due to changes in wave length of the radiation. An increase of gene mutation rate up to a dose of 400 r was parallel to the quantity of radiation. Then the curves of all radiation qualities show a drop as far as 1,600 r, then a rise follows up to a dose of 3,200 r. The drop after a dose of 400 r occurred in each case even where the pollen was irradiated on a different apparatus. A satisfactory explanation for the mutation curve is impossible at present. Perhaps the radiation acts differently on portions of the cell nucleus which may have varying radiosensitivities so that they mutate in the one case at a dose of 400 r, in the other with a dose of 3,200 r. In each of these values the degree of mutability must be limited if there is to be a living gamete. If these limits are exceeded by higher quantities of radiation then the markedly damaged, that is mutated, pollen nuclei are eliminated; the rate of mutation drops. In the case of Antirrhinum in the constance of the genes there is no fluent transition from labile through all degrees of stability to highly stabile ones but there are genes which mutate easily under changed external conditions and genes that mutate only with the greatest difficulty under extreme conditions of change. After irradiation with 400 r, 78 per cent of all genes were of multiple occurrence and only 22 per cent single. With higher doses the percentage of labile genes decreases and the fraction of new genes increases. With irradiation with 3,200 r the relationships were reversed. These findings seem important in regard to the question of damage to the germ

cells after radiotherapy because they seem to show, in contrast to the usual view, that there is no definite progression of the rate of mutation with the dose and that mutations often occur with relatively low doses (400 r) and that in general they are the same as those spontaneously occurring in any strain. When we take into consideration man with genes of varying stability—and there is no doubt that this is the case—to whom roentgen rays may be administered in doses of varying degree in therapy or diagnosis mutations may be produced in various loci and therefore it is very likely that in a race of human beings recessive genes are split off homozygotically and so become manifest even when no near relatives are included.—*E. T. Leddy.*

Vierheller, F., and Saralegui, J. Beitrag zur Kenntnis des Röntgenspektrums. (Some studies of the roentgen spectrum.) *Strahlentherapie*, 1933, *47*, 43.

This is a prelininary report of the theoretical explanation of some hitherto unrecognized lines which the authors have demonstrated in the K-series and in the zone of continuous blackening in the Seemann spectrogram.—*E. T. Leddy.*

Küstner, H. Die Elektronenemission der Metalle unter Einwirkung der Röntgenstrahlen. (Electron emissions of metals produced by roentgen rays.) *Strahlentherapie*, 1933, *47*, 35.

Electron emission from metals by roentgen rays is an important subject to both the physicist and the physician for this phenomenon is the basis for many important problems, for example sensitization of tissue by introducing substances of high atomic weight, and the hardness factor of ionization chambers. Küstner presents some curves of electron emission of some of the common metals and shows that many of the discrepancies between theory and experience can be best studied by monochromatic roentgen rays and special ionization chambers.—*E. T. Leddy.*

Grebe, L., and Huppertsberg, A. Roentgenstrahlenmessungen mit Zählrohren. (Roentgen-ray measurements with counting chambers.) *Strahlentherapie*, 1933, *47*, 25.

The authors describe some experiments on roentgen-ray measurements with the Geiger counter, the applicability of which was pointed out by Rutherford and Geiger and by Geiger and Müller (*Physik. Z.* vol. 10, and vol. 29) and state that the method is most useful when small quantities of roentgen rays are to be measured. In studies of protection where the intensities of roentgen rays are about 10^{-5} r/sec direct measurements can be made by this method. In such a case the connection of the counter to a loud speaker will demonstrate in a very spectacular manner that the safety limit for protection has been exceeded.—*E. T. Leddy.*

Langendorf, Hand M., and Reuss, A. Über die Wirkung von Röntgenstrahlen verschiedener Wellenlänge auf biologische Objekte. V. (The effect of roentgen rays of various wave lengths on biological objects. IV.) *Strahlentherapie*, 1933, *46*, 655.

In this paper the authors review some experiments they performed on algae with radiations of different qualities. They find that the curves of damage to algae from roentgen rays from 0.56 Å to 1.54 Å have the same shape but the half-value doses vary in the ratio of 1.8:1. There is very little difference between the roentgen-ray damage curve and that of ultraviolet light. The effect of the time factor on algae is a very slight one. The Schwarzschild exponent is not less than 0.98—possibly even 1.0.—*E. T. Leddy.*

Glocker, R., and Reuss, A. Über die Wirkung von Röntgenstrahlen verschiedener Wellenlänge auf biologische Objekte. V. (The effect of roentgen rays of various wave lengths on biological objects. V.) *Strahlentherapie*, 1933, *47*, 28.

In previous papers in this journal Glocker and his associates have shown in their investigations of the dependence of the shape of damage curve on wave length that there was a difference in the case of beans, but none in the case of axolotl eggs, yeast and algae. It seemed desirable, therefore, to investigate other plants in this regard. In the present paper the authors state that the injury curve of mustard seed and sunflower seed changes its shape in the same way as does that of beans with changes in roentgen-ray quality from 0.56 Å to 1.54 Å. The course and the magnitude of the changes are in agreement with the range of electrons according to the impact theory.—*E. T. Leddy.*